HACKENSACK MEADOWLANDS DEVELOPMENT COMMISSION'S
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August 28, 2001

Seth Ausubel
USEPA
290 Broadway
19th Floor
NY, NY 10007-1866

Dear Seth,

Here are some oldies, and I hope goodies, from our files. Sorry there's nothing recent.

In chronological order:

1. J. McCormick & Associates. 1977. Collections of aquatic organisms from the Hackensack Meadowlands...
2. Sabounjian, E., and Galluzzi, P. 1980. Mercury concentrations in fish ...
3. Galluzzi, P. 1981. Mercury concentrations in mammals...
4. Konsevick, E. 1985. Mercury in biota.
5. Santoro, E., and Koepp, S. 1986. Mercury levels in organisms...
6. Bragin, B. et. al. 1989. Inventory of fisheries (relevant section only).
7. Konsevick, E. 1989. Berry's Creek Mercury in biota data summary.

Glad to be of assistance.

Sincerely,

Edward Konsevick

1977-001
#168

Ventron PO 049294
JMA Project No. M168

1 March 1977

COLLECTIONS OF AQUATIC ORGANISMS FROM THE HACKENSACK MEADOWLANDS, BERGEN AND HUDSON COUNTIES, NEW JERSEY

Submitted to:

Mr. Joseph H. Bernstein
Vice President, Operations
Ventron Corporation
Chemicals Division
Beverly MA 01915

823650002

JACK McCORMICK & ASSOCIATES, INC.
a subsidiary of WAPORA, Inc.

Collections of Aquatic Organisms

From the Hackensack Meadowlands, New Jersey

EXECUTIVE SUMMARY

Analyses of sediments from several locations in the central Meadowlands indicated that mercury (total) is present in stream bottoms and marshes in concentrations which range from <1.0 ppm to nearly 8,500 ppm. Few tests of biological materials were available, and the results were contradictory. The purpose of this project was to obtain a large number of biological samples from the waters and wetlands at eight stations in the central section of the Meadowlands. Stations were selected on Berrys Creek and on the Hackensack River near, and downstream from, the mouth of the Berrys Creek Canal. The locations of the stations are shown on Figure 1.

Approximately 700 biological samples were collected during the week of 18 October 1976. Only common reed (a grass), killifish (which are minnows), and detritis samples were collected from all eight stations. Organisms of each of the other species were collected at five or fewer stations. The uneven distribution of these species probably is related at least to four factors. Certain species, such as the blue crab, were retreating to deeper waters for the winter, and had withdrawn from their more extensive warm-season distributions. There also is a marked north to south gradient in the degree of contamination of the channel and marsh sediments, and some species may not be able to colonize the more northern areas. Furthermore, the concentrations of dissolved oxygen occasionally are low (to 0.0 ppm)

in Berrys Creek near Stations A, B, and C, and some organisms may not be able to tolerate such conditions.

The specimens have been identified, labelled, packaged, and frozen for storage. Under another contract, the concentrations of mercury in these samples will be determined. It is anticipated that these tests will be completed before 1 June 1977.

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1. Introduction

Since 1972, Jack McCormick & Associates, Inc., has conducted a series of analyses to detect and describe the distribution of mercury in stream channel and wetland sediments in the central section of the Hackensack Meadowlands District, New Jersey. These investigations, which are sponsored by the New Jersey Sports and Exposition Authority, have revealed that abnormally high concentrations of total mercury are present in the sediments, that the contamination is widespread throughout the region, and that there is a gradient of concentrations from the upstream areas on Berrys Creek (highest) to Sawmill Creek (lowest).

The information developed to describe the levels of mercury in sediments raised questions in regard to the biota. Only a few data are available for aquatic animals, and these suggest that mercury is not rapidly entering the local food chain. Tests of three muskrats, two killfish, and one blue crab indicated that the animals contained slightly elevated concentrations of mercury, but that the concentrations did not exceed the maximum of 0.5 ppm allowed in meat destined for human consumption. Tests of roots of marsh plants, in contrast, suggested that they may contain mercury in concentrations as high as 170 ppm.

These tests suggest that the mercury may be in a relatively inert form that does not constitute an immediate or significant threat to the human or wildlife populations of the region. Owing to the sparsity of data, however, no definitive conclusion can be drawn from the information currently avaliable.

2. Purpose of This Investigation

The purpose of this investigation is to obtain samples of a variety of organisms from the streams and wetlands of the Hackensack Meadowlands District, to sort, identify, and enumerate the samples, and to preserve them for later analyses to determine their mercury content. The field and laboratory work described in this report are sponsored by the Ventron Corporation, Beverly, Massachusetts, to insure that appropriate samples are collected during the 1976 period of biological activity.

No analyses for mercury were included in the scope of work for this field and laboratory investigation. Such analyses, however, will be initiated during December 1976 under the aegis of the New Jersey Sports and Exposition Authority. A plan of study for the analyses has been reviewed and approved by the Hackensack Meadowlands Development Commission and the New Jersey Department of Environmental Protection. The United States Environmental Protection Agency, Region II, also has concurred in the need for analyses.

3. Materials and Methods

3.1. Station Locations

Eight collection stations were selected in the central section of the Hackensack Meadowlands District (Figure 1). These stations are located at or near points from which sediment cores previously were obtained for mercury analyses. The distribution of stations thus assures the collection of organisms that have been exposed to a range of mercury levels in the sediments.

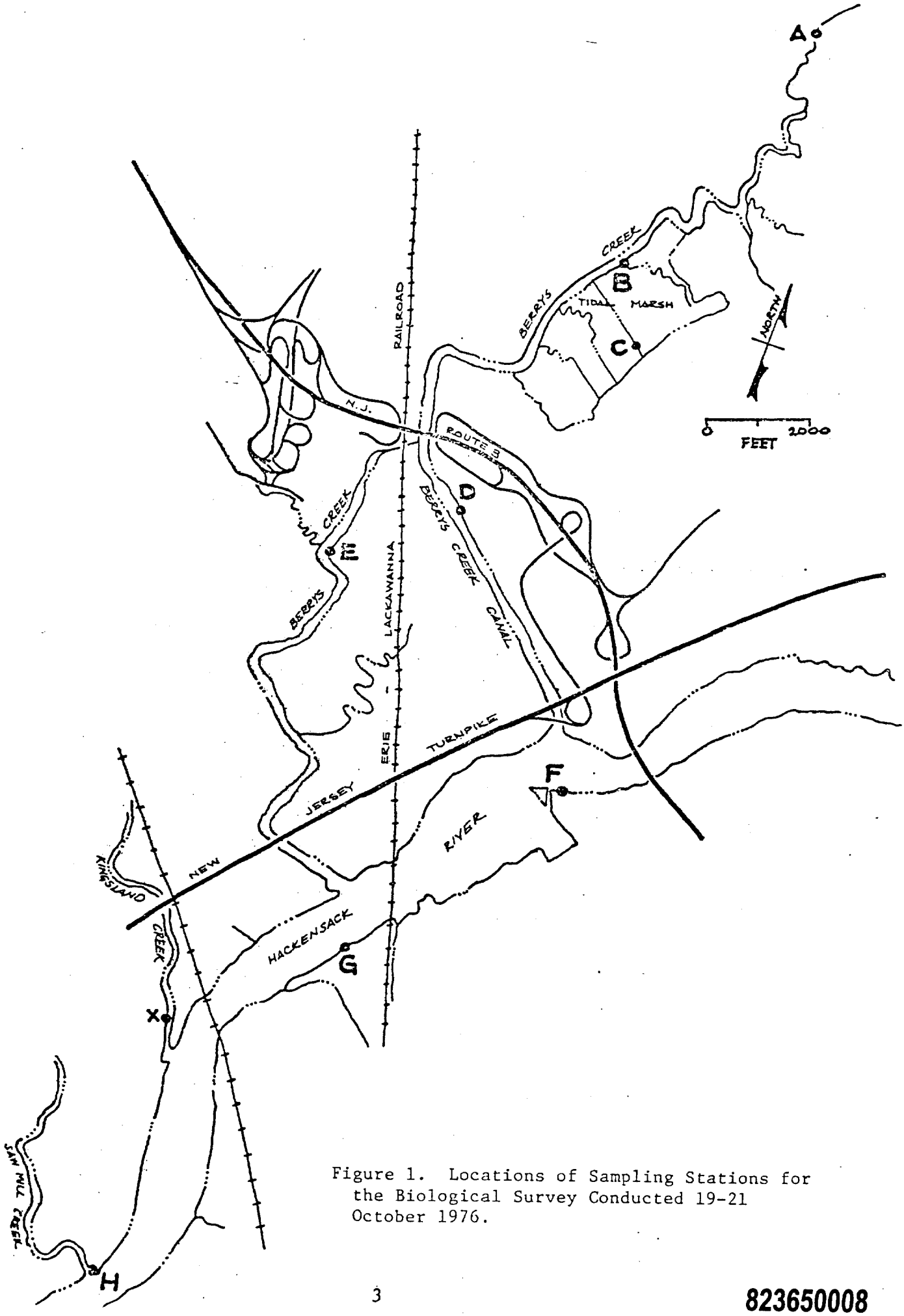

Figure 1. Locations of Sampling Stations for the Biological Survey Conducted 19-21 October 1976.

The locations of collection stations are shown in Figure 1, and narrative descriptions of the locations are given in Table 1. Letter designations were assigned in geographic order to facilitate textual descriptions. During actual collections, however, the stations were numbered in the order that they were sampled. The field station numbers are included in Table 1 and correlate with data recorded on specimen labels and in field notebooks.

3.2. Sampling Methodology

A biological field survey was conducted 19-21 October 1976 at the stations listed in Table 1 and illustrated in Figure 1. Table 2 presents a field schedule indicating station locations, tasks completed, and dates of completion. Many sampling methods were used with the intent of obtaining as diverse a collection of organism as possible. Field work was started with the intention of collecting at least ten different biological species (in triplicate) from each of eight sampling locations. In actual practice, when a number of individuals of the same species was collected, usually more than three were packaged and stored. Because the goal of this investigation was to sample in different habitats in order to collect different kinds of organisms, the collections were of a qualitative rather than quantitative nature. While the results of this study may not be used to project population estimates for any of the species collected, effort was made to record general relative abundance estimates for the species found at the various sampling locations. The following discussion outlines the procedures used to collect organisms during the survey.

Table 1. Descriptions of Sampling Station Locations for the Biological Survey Conducted 19-21 October 1976.

Station No.	Location Description
A	Upper Berrys Creek, approximately where the town line separating the towns of Moonachie and Carlstedt crosses Berrys Creek; just downstream from the tide gates (Field Station 5).
B	East bank of Berrys Creek approximately 200-300 yards upstream from the mouth of the southeast-northwest canal through the tidal marsh (Field Station 4).
C	Narrow, straight canal running approximately southeast to northwest through Berrys Creek tidal marsh, approximately 3/4 of the distance from Berrys Creek along the canal toward the dike surrounding the marsh (Field Station 3).
D	Northeast bank of Berrys Creek Canal, approximately 0.3 mile downstream from the Route 3 bridge (Field Station 2).
E	East bank of Berrys Creek, immediately north of the point approximately 0.5 mile south of Route 3 (Field Station 7).
F	East bank of the Hackensack River directly opposite the mouth of Berrys Creek Canal (Field Station 1).
G	East bank of the Hackensack River, approximately 0.2 mile downstream from the Erie-Lackawanna tracks which cross the Hackensack immediately upstream from the mouth of Berrys Creek (Field Station 8).
H	West bank of the Hackensack River at the northern point formed by the confluence of Sawmill Creek (Field Station 6).
X	West bank of Kingsland Creek, approximately 200 yards upstream from the confluence with the Hackensack River.

Table 2. Schedule of Field Activities, 19 through 21 October 1976

Date	Station	Tasks Completed
19 October 1976	B	Set hoop net
	C	Set hoop net Set seine Fish collections (dip net)
	D	Tow net collections Plankton collections Terrestrial hand picking[a] Shoreline (mudflat) hand pickin Benthos collections (dredge) Vegetation collections Fish collections (dip net)
	F	Plankton collections Terrestrial hand picking Shoreline (mudflat) hand pickin Benthos collections (dredge)
20 October 1976	A	Plankton collections Terrestrial hand picking Shoreline (mudflat) hand pickin Benthos collections (dredge) Set pitfall and snap traps Vegetation collections (dip net)
	B	Plankton collections Terrestrial hand picking Shoreline (mudflat) hand picking Benthos collections (dredge) Set pitfall and snap traps Vegetation collections Checked and reset hoop net

[a] The word "terrestrial" is used to describe marsh-surface investigations.

Table 2. Field schedule (continued).

Date	Station	Tasks Completed
20 October 1976	C	Plankton collections Terrestrial hand picking Shoreline (mudflat) hand picking Benthos collections (dredge) Set pitfall and snap traps Vegetation collections Retrieved seine Checked and reset hoop net
	D	Set pitfall and snap traps
	E	Set pitfall and snap traps
	X	Set pitfall and snap traps
21 October 1976	A	Retrieve traps Fish seine collections
	B	Retrieve traps Retrieve hoop net Otter trawl collections
	C	Retrieve traps Retrieve hoop net
	D	Retrieve traps Fish seine collections Otter trawl collections
	E	Plankton collections Terrestrial hand picking Shoreline (mudflat) hand picking Retrieve traps Vegetation collections Otter trawl collections
	F	Vegetation collections Otter trawl collections
	G	Plankton collections Terrestrial hand picking Shoreline (mudflat) hand picking Vegetation collections Otter trawl collections

Table 2. Field schedule (concluded).

Date	Station	Tasks Completed
21 October 1976	H	Plankton collections Terrestrial hand picking Shoreline (mudflat) hand picking Benthos collections (dredge) Vegetation collections Otter trawl collections Tow net collections
	X	Retrieve traps

3.2.1. Fish

The equipment used for fish collections included a 16-foot otter trawl, 40-foot and 20-foot seines, hoop nets, dip nets, and a tow net. The most effective collecting device was the otter trawl. It consisted of a wide-mouth net which was towed behind the boat for a period of three to five minutes. The material entrapped was concentrated in a fine-meshed bag located inside the trawl net. This collection method was usually effective in collecting not only fish, but a variety of other aquatic organisms.

Hoop nets were set up at two locations to collect larger fish species. When the net is in place, it extends horizontally below the surface of the water with one end open and the other end closed. These nets are often baited, but this is not absolutely necessary. The nets were not baited during this study.

Seines were used in various ways to collect fish. At one location, a seine was set up as a block across a narrow canal (Station 3) to trap fish at low tide. At other locations, the larger seine was used to swing an arc through the water. One end of the seine was held in the boat, while the other end was held on the shore and acted as the pivot point.

The dip net was used frequently to collect small fish near the shoreline or near the surface. The tow net is a much smaller version of the trawl (used in the same fashion), and it was used at several locations. It was not as effective as the trawl in collecting organisms.

3.2.2. Aquatic Macroinvertebrates

As mentioned previously, the otter trawl was quite effective in collecting organisms other than fish such as crabs and shrimp. In addition, a Ponar dredge was used to supplement the trawl collections. Generally, triplicate bites were collected, washed, and sorted in search of burrowing aquatic forms. Burrowing forms also were collected by hand picking along the shoreline or mudflats. Evidence of burrowing animals would result in turning over and sorting through mud samples at numerous shoreline locations. Rocks or rotten limbs that were regularly covered by water at high tide were investigated for the presence of organisms.

3.2.3. Marsh Invertebrates

Worms, spiders, insects, amphipods, isopods, and other invertebrates were collected from marsh areas and, where no marsh terrain was present, from areas adjacent to the stream bank. The surface of the soil and plant stems were inspected closely. Plant roots, rocks, limbs, and other debris also were examined to obtain specimens.

3.2.4. Plankton

Plankton samples were collected at each sampling location by pouring approximately 40 gallons of water through a fine-meshed plankton net. The concentrated sample was collected in a small vial attached to the closed end of the net. Conspicuous mats of sessile algae along shorelines were also sampled if present.

3.2.5. Mammals

An attempt was made to sample terrestrial mammals such as voles, shrews, and field mice by using pitfalls and snap traps. Wide-mouth quart jars were used as pitfall traps and were buried so that the rim was level with the ground. Snap traps were baited with peanut butter. Two snap traps and twoppitfall traps were placed at the station locations and were left overnight. All traps were examined within 24 hours of placement.

3.2.6. Plants

At each sampling station collections were made of the predominant types of rooted plants. Triplicate samples of the predominant species in each area were collected. The leaves, stems, and roots of each specimen were packaged separately.

3.2.7. Sample Preservation and Storage

Collected samples were immediately placed in ice coolers. No other preservation techniques were appropriate as chemical preservatives would make subsequent mercury analyses invalid. The iced samples were transferred to a freezer for storage as soon as possible.

In the laboratory, the collected specimens were sorted, identified, and enumerated. The specimens then were stored in a freezer until analyses for mercury are initiated.

4. Results and Discussion

The organisms collected at the sampling stations during this study are listed in Table 3. An "X" indicates the collection of a plant specimen or an unquantified number of specimens. The summary data reported at the end of the table should be evaluated carefully. In evaluating the biological health of the stations, the number of species found during this study is more important than the reported number of individuals preserved. Sampling was not quantitative, and many individuals collected at each station were discarded. The following discussions provide descriptions of the areas sampled and the organisms collected.

4.1. Berrys Creek and Tidal Marsh Stations

4.1.1. Station A

This station is located in the area in which the concentrations of mercury in the sediments are greatest. All exposed surfaces were coated with petroleum products, and odors in the area were offensive. The marsh and channel substrates consisted of black muck that contained noticeable deposits of petroleum products.

The majority of the collections at Station A were conducted during a steady rain at a period of falling tide. Of the 69 organisms preserved, 51 were killifish, which was the only species of fish collected. The sediments were nearly devoid of organisms, and no invertebrates other than barnacles were found along the shoreline. Samples of common reed grass and low water cordgrass were collected, and a house mouse was captured in c of the snap traps. This was the only small mammal collected in snap traps or pitfalls at the sampling stations.

Table 3. Inventory of organisms collected from the Hackensack Meadowlands, 19-21 October 1976.

Scientific Classification	Common Name	Stations							
		A	B	C	D	E	F	G	H
Plants									
Phragmites communis	Common Reed Grass	X	X	X	X	X	X	X	X
Spartina alterniflora	Low Water Cordgrass	X	X					X	
Typha	Cattail		X						
	Blue Green Algae						X		
	Unidentified Grass	X							
	Plankton	X	X	X	X	X	X	X	X
Macroinvertebrates									
Phylum Rhynchocoela (unidentified non-segmented worm)							1		
Phylum Mollusca									
Class Gastropoda									
Subclass Pulmonta									
Order Basommatophora									
Family Ellobiidae									
Melampus bidentatus	Marsh snail		1				1		
Class Bivalvia									
Subclass Teleodesmata									
Order Heterodontida									
Family Dreissenidae									
Congeria leucopheata	False mussel			3			25		

Table 3. Inventory of organisms collected from the Hackensack Meadowlands, 19-21 October 1976 (continued)

Scientific Classification	Common Name	Stations A	B	C	D	E	F	G	H
Phylum Arthropoda									
Class Insecta									
Order Diptera									
Unidentified early instar larvae							14		
Class Crustacea									
Subclass Cirripedia									
Order Thoracica									
Suborder Balanomorpha	Acorn Barnacles								
Family Balanidae									
Balanus improvisus		17	100	55	11		103		
Subclass Malacostraca									
Order Isopoda	Sow Bugs								
Suborder Anthuridea									
Family Anthuridae									
Cyathura polita							1		1
Suborder Onoscoidea									
Family Onoscoidae									
Philoscia vittata			3						
Order Amphipoda	Scud								
Suborder Gammoridea									
Family Talibridae									
Orchestia grillus			7		15				1

Table 3. Inventory of organisms collected from the Hackensack Meadowlands (continued).

Scientific Classification	Common Name	Stations							
		A	B	C	D	E	F	G	H
Order Decapoda									
Infraorder Caridea	Caridean Shrimp								
Family Palaemonidae									
Palaemonetes pugio	Grass Shrimp		6		10		65*	129*	11*
Family Crangonidae									
Cragon septemspinosa	Sand Shrimp					7		1	2
Infraorder Brachyura	True Crabs								
Section Brachyrhyncha									
Family Portunidae									
Callinectes sapidus	Blue Crab							3	
Family Xanthidae									
Phithropanopeus harrisii	Mud Crab				13	5	13*		1
Family Ocypodidae									
Uca pugnax	Fiddler Crab							1	5
Fish Class Osteicthyes	Bony Fishes								
Order Anguilliformes									
Family Anguillidae	Freshwater Eels								
Anguilla rostrata	American Eel					1	1		
Order Clupeiformes									
Family Clupeidae	Herrings								
Alosa pseudoharengus	Alewife							1	

Table 3. Inventory of organisms collected from the Hackensack Meadowlands (concluded).

Scientific Classification	Common Name	Stations A	B	C	D	E	F	G	H	Total
Order Cypriniformes										
Family Cyprinidae	Minnow and Carps									
Carassius auratus	Goldfish					1				
Order Atheriniformes										
Family Cyprinodontidae	Killifish									
Fundulus spp.		51	3	18	15	5	7*	8*	4	
Order Perciformes										
Family Sciaenidae	Drums									
Leiostomus xanthurus	Spot						1	7	1	
Rodent *Mus musculus*	House mouse	1								
Summary for Aquatic Animals, By Station										
Invertebrates										
Number of Species		1	5	2	4	2	8	4	6	13
Number of Individuals Collected		17	117	58	49	12	223	134	17	527
Fish										
Number of Species		1	1	1	1	3	3	3	2	6
Number of Individuals Collected		51	3	18	15	7	9	16	5	124
All Animals										
Number of Species		3	6	3	5	5	11	7	8	19
Number of Specimens		69	120	76	64	19	232	150	22	657

Note: Samples of grasses and cattail were collected at least in triplicate.

* Indicates that numerous additional specimens were observed at the station, but were not collected.

4.1.2. Station B

Station B is adjacent to the tidal marsh on Berrys Creek between Paterson Plank Road and Route 3. The habitats here did not appear to be as degraded as those at Station A. The sediments in the channel and marsh consisted of black muck and detritus with noticeable oil deposits, and they emitted an offensive odor. Isolated patches of brown clay also were detected in the area, and the condition of the sediments generally was judged to be better than that of sediments at Station A.

Most of the collections at Station B were obtained during a steady rain and on a rising tide. Of the 120 organisms preserved from the area, more than 100 were barnacles. The killifish was the only species of ;h collected. No fish were caught in a hoop net which was placed in a drainage canal that extended through the marsh to Berrys Creek immediately upstream from Station B. Shrimp were sparse in the trawl and dredge collections. Invertebrates collected from the tidal marsh included a few sow bugs and scuds and one snail.

4.1.3. Station C

Station C is isolated in a narrow canal that extends through the Berrys Creek tidal marsh. The conditions of the habitats at this location were similar to those at the nearby Station B on Berrys Creek. A slight odor was detected, and oil coated exposed surfaces. The channel and marsh sediments consisted of black muck and detritus, and petroleum deposits were present. As was the case at Station B, patches of a brown clay bstrate were present.

The majority of the samples at Station C were collected during a steady rain and on a rising tide. As at Station A, only three types of aquatic animals were obtained. The apparent low diversity of species may be related to the fact that Station C was located in a dredged canal. The banks and parts of the bottom of the canal were exposed at low water slack. Substrates at stations on creeks and the Hackensack River were less exposed. Of the 76 organisms preserved, 55 were barnacles that were removed from the surfaces of decaying limbs. The killifish was the only species of fish observed in samples obtained by seining and dip netting. No fish were collected in the hoop net, and the area was too shallow for trawling. No aquatic invertebrates were found in the marsh sediments. Common reed grass was the predominant plant species in the area.

4.1.4. Station D

Samples at Station D were collected from Berrys Creek Canal. This station was similar to Station B in appearance, except that the canal is somewhat wider than Berrys Creek at Station B. The channel and marsh sediments were quite odorous, and consisted of black muck with substantial petroleum deposits. The petroleum odor, however, was not as strong as that at Station B.

Most of the biological collections were made on a rising tide during clear weather (19 October). The killfish was the only species of fish collected. Aquatic invertebrates found in dredge and trawl samples included shrimp and crabs. These invertebrates were not abundant in

the samples, and all or most were preserved. Scuds were the most abundant invertebrates found by hand picking in the marsh. Common reed grass was dense along the banks of the canal and was collected as the predominant plant species in the area.

4.1.5. Station E

Station E is located along the southern section of Berrys Creek in an area characterized by extensive mud flats which form a shallow shelf that extends toward midchannel. The sediments consisted of soft brown clay and detritus infused with a small amount of petroleum products. No strong petroleum odor was apparent.

The collections at Station E yielded a total of five types of aquatic animals. In addition to killifish, one goldfish and one eel were obtained. Shrimp and crabs were the only aquatic invertebrates collected. Relatively few organisms were obtained, and virtually all of the specimens were preserved.

4.2. Hackensack River Stations

4.2.1. Station F

Station F is on the Hackensack River opposite the mouth of Berrys Creek Canal. Petroleum products were evident on the surface of the water, and an unidentified blue substance coated surfaces along the shoreline. The marsh and channel-bottom sediments consisted of clay and abundant detritus.

Most of the collections were made on a falling tide. More types of organisms were collected (11), and more individuals were preserved (232) at Station F than any other station. More than 100 of the organisms preserved were barnacles, and 65 were grass shrimp. In addition to seven killifish, one spot and one eel were preserved. Many other killifish and thousands of other shrimp that were captured during trawls were returned to the water. Thirteen mud crabs were collected from mudflats along the shoreline, but many others were present. Early instar insect larvae and sow bugs were the predominant forms collected from the tidal marsh by hand picking. Common reed grass was the predominant rooted plant. No traps could be set for mammals because of high water on 20 October.

4.2.2. Station G

Station G is located on the Hackensack River opposite the mouth of Berrys Creek. Oil products were evident on the surface of the water, but no offensive petroleum odors were noted. The channel and marsh sediments were composed of brown mud and detritus. Mud flats that extend from the shoreline toward midchannel form a shallow shelf.

All collections were made on a rising tide during partly cloudy weather. Of the 150 organisms preserved, 129 were grass shrimp from trawl samples. Thousands of other shrimp were returned to the water. Individuals of three species of fish were collected: killifish, spot, and alewife. Killifish were abundant in the hauls, and most were returned to the water. Three blue crabs were collected at Station G, but none was found at the other sampling stations. Common reed grass was the predominant plant along the shoreline. No traps could be set for mammals at this site owing to high water in 20 October.

4.2.3. Station H

Station H is near the confluence of Sawmill Creek and the Hackensack River. No petroleum odor was detected, but patchy oil films were present on near-shore surface waters. The channel and marsh sediment consisted of muck, detritus, and some sand. No oil was noticeable in the substrate.

The collections were obtained on a rising tide during partly cloudy weather. Shrimp were numerous in the trawl samples, but they were not as abundant as those at Stations F and G. Killifish and spot were the only species of fish observed. Mud crabs and fiddler crabs were the predominant large aquatic invertebrates present, but few were captured. Hand picking from the vegetation yielded one sow bug and one scud. Common ed grass was predominant in the vegetation of the area. Because traps could not be set for small mammals at this site owing to high water, they were placed on more elevated ground upstream, near the mouth of Kingsland Creek (Station X, Figure 1). No specimens were obtained.

5. Summary

Approximately 700 biological samples, including 657 macroscopic aquatic animals, 1 mammal, 39 rooted vascular plants, and 3 algal masses, were collected from the waters and wetlands at eight stations in the central section of the Hackensack Meadowlands District, New Jersey, during the period from 19 through 21 October 1976. Acorn barnacles (286 specimens), grass shrimp (221 specimens), and killifish (111 specimens) were the most abundant of the organisms that were enumerated separately. etritus samples also were obtained from each of the eight stations.

The purpose of this investigation is to obtain, identify, enumerate, and preserve a representative assemblage of aquatic organisms from the Meadowlands District before the end of the 1976 period of maximum biological activity. Owing to the previous detection of high levels of mercury in sediments in the streams and wetlands of the region, it is considered to be imperative to examine a wide range of aquatic organisms to determine whether or not the mercury is moving rapidly into and throughout the food web. Actual tests for mercury in the specimens were not included in the scope of this work, but will be initiated during December 1976 under another contract.

The sampling was not intended to yield precise quantitative measures of species populations at the various stations. Observations made by the field investigators, however, do provide a relative, qualitative measure of the patterns of species distribution in the region and of variations in the faunal density and diversity from station to station during late autumn.

Only the killifish was observed at every station that was sampled. The abundance of these minnows varied from station to station, with the greatest numbers at stations on the mainstem of the Hackensack River. The fish are mobile, however, and large populations may appear at any of the stations from time to time.

Grass shrimp were observed at five of the eight stations, and also were most abundant at stations on the mainstem of the Hackensack River. As the killifish, the shrimp are mobile and may appear at any of the stations in large numbers.

Mud crabs were collected at the two most downstream stations in the Berrys Creek system, at Station F on the Hackensack River, and at the station at the mouth of Sawmill Creek. Except for the lack of specimens from Station G and their relative abundance at Station D, the distribution of this burrowing crab may reflect the degree of pollution of the sediments.

Acorn barnacles also were collected from four stations. They were observed at many other places, and are distributed throughout the Meadowlands District. The barnacles are sedentary and apparently become established in the intertidal zone wherever suitable hard substrates are available.

The distribution of other invertebrates was spotty, and each was observed at one to three stations. The general scarcity of marsh snails and other surface dwellers probably was related to the lateness of the season. The lack of fiddler crabs, which are burrowers, at stations in the Berrys Creek system may be related to the pollution of the sediments.

Blue crabs are numerous enough to attract many sport fishermen during the summer months. They are common in the Sawmill Creek area and along the Hackensack River, and have been observed on Berrys Creek at least as far upstream as the Paterson Plank Road bridge (between Stations A and B). This is a mobile species and, with the killifish and shrimp, may have begun to move to the Hackensack River from the smaller streams as the season advanced and temperatures dropped.

The large fish -- American eels, alewife, goldfish, and spot -- were observed at the most downstream station (E) on Berrys Creek, in the mainstem of the Hackensack River, and at the mouth of Sawmill Creek. This distribution also may correlate with the gradient of pollutants in the sediments, and/or may reflect a tendency for the fish to seek the deeper water of the mainstem of the Hackensack River during the autumn. Daily measurements of water quality near Stations B and C also have indicated frequent and prolonged conditions of oxygen depletion in the upstream section of Berrys Creek. The lack of observations of the larger fish in that section, thus, may reflect the absence of a suitable water environment.

Generally, the collections and related observations suggest that the diversity of larger aquatic animals is greatest at stations sampled on the mainstem of the Hackensack River. The fauna of Berrys Creek, particularly in the upstream sections represented by Stations A, B, and C, appears to be impoverished. Previous investigations and qualitative observations during this project have revealed that sediments in this upstream section are more heavily contaminated than are those elsewhere in the region. The chemical stresses in the upstream section of Berrys Creek are aggravated further by the frequent depletion of dissolved oxygen in the water.

6. Personnel

The scope of this project was planned by Dr. Jack McCormick, President of the company, who is a graduate ecologist. Dr. Frank A. Camp, Vice President and graduate aquatic biologist, determined the methodology. Mr. Paul Galluzzi, who has been in charge of JMA operations in the Meadowlands District since 1973, identified the stations to be sampled. Station locations and the general concept of the work were reviewed and approved by the staff of the Hackensack Meadowlands Development Commission and the New Jersey Department of Environmental Protection.

The field work and subsequent laboratory work were directed by Dr. Camp. He was assisted in the field by Mr. Paul Galluzzi, who holds a Master's degree in biology, and Mr. William Ressler, who holds a Master's degree in estuarine ecology. Mr. Ressler conducted most of the laboratory work.

The report was drafted by Dr. Camp. Dr. McCormick revised the report, and Mr. Ressler reviewed it for technical accuracy.

Approved by:

Jack McCormick, Ph.D.
President

Submitted by:

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MERCURY CONCENTRATIONS IN FISH AND AQUATIC FROM THE HACKENSACK MEADOWLANDS, NEW

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Abstract

Fish and aquatic invertebrates were collected from the Hackensack Meadowlands, Bergen and Hudson Counties, New Jersey, and analyzed for total mercury concentrations by cold vapor atomic absorption spectrophotometry. Tissue concentrations ranged from 0.0 ppm to 3.8 ppm total mercury. Results indicate relatively high mercury contamination in fish and invertebrates, albeit not as great as would be expected for an area with known high sediment contamination. The fish data, particularly killifish (Fundulus sp.), suggest that larger and/or older fish have greater concentrations of mercury. Mercury contamination of fish seems to be more pronounced in the southern sampling area, furthest from the highest sediment contamination. Fiddler crabs (Uca sp.) may be a good environmental indicator of local mercury contamination.

Introduction

During recent years, concern over the presence of mercury in the environment, particularly that which may be available for human contamination, has heightened. To prevent exposure to humans, the Federal food and Drug Administration adopted an interim standard of 0.5 ppm (parts per million) total mercury in fish sold commercially for human consumption. This has since been raised to 1.0 ppm.

Areas of greatest scrutinay are those which have documented evidence of mercury pollution and are located near large population centers. This study was conducted on one such locality in the Hackensack Meadowlands District, New Jersey, a 19,000 acre area of tidal and freshwater marshland and estuary. A mercury processing plant is known to have operated for over 40 years on the banks of Berrys Creek west riser ditch, in the north west section of the District (New Jersey Department of Environmental Protection, 1976).

Methods

Fish and some aquatic invertebrates were collected and analyzed from throughout the District from July, 1977 through November, 1978. Wet weight samples of muscle, liver, kidney, carapace, and viscera were analyzed for total mercury by flameless atomic absorption spectrophotometry. Procedures follow Uthe, 1970; Perkin-Elmer, 1971; Koch and Manning, 1977; and Beaty, 1978.

To insure the accuracy of the analyses, split samples were analyzed by laboratories at the New Jersey Department of Health and the New Jersey Institute of Technology. In addition, anaylses were performed on three sets of mercury reference samples obtained from the U. S. Environmental Protection Agency.

Results

Four hundred seventy nine specimens, of fourteen fish species, were collected on which mercury analyses were performed. Total mercury concentrations within the muscle tissue of each specimen was measured to provide a common yardstick of comparison. Due to small fish size, many of the muscle tissue analyses were performed on composite samples which generally represented five fish, whith few exceptions. Mercury concentrations within kidney and liver tissue was determined on some of the larger fish, on a less regular basis, to give some indication of the relative abundance of mercury in some other fish tissues or organs. Concentrations of mercury in the tissue samples, of which 408 were killifish (Fundulus sp.), ranged from 0.0 ppm in several species, to 3.8 ppm in liver tissue from an american eel (Anguilla rostrata). Tables 1. through 3. display frequency distributions of concentrations by fish species. Tables 4. through 7. represent a concentration frequency distribution by stations.

Among the 408 killifish analyzed, 96% were below the original FDA standard of 0.5 ppm. No killifish samples were observed to exhibit more than .898 ppm mercury. No obvious gradient or geographical pattern of mercury contamination among the killifish population was observed. Relatively high values were observed at almost every location, with the Berrys Creek area samples not particularly high related to the other sites. However, some qualified generalizations can be made concerning mercury distribution in the killifish population. Comparing the sampling sites (Figure 1.) with the average mercury concentration in killifish muscle at each station (Table 4.), it appears that the fish collected from stations 1 through 7, located in the northeast section of the sampling area, have on-the-whole the lowest concentrations of mercury. Likewise, the stations closest to Newark Bay (18 through 23) tend toward the highest mercury concentrations within the killifish population. The mercury concentrations within the other fish species at these various sampling stations also support these conclusions concering geographical distributions of mercury within Mewdowlands fish.

Figure 3., which represents the concentration of mercury in killifish muscle as a function of fish size (length), indicates a relationship between fish size and concentration of mercury within the muscle tissue. Although the data points are scattered, and are skewed to the right with increasing mercury concentration, an obvious pattern toward increased mercury concentration as the fish become larger can be seen.

Among the higher order fishes, a greater percentage of the specimens fell into the 0.5 to 1.0 ppm, and greater than 1.0 ppm ranges. The greatest concentration of mercury found in muscle tissue was 1.877 ppm observed in a white perch (Morone americana) collected from Berrys Creek Canal. In gereral, the concentrations of mercury in these other fish species are higher than typically found in killifish.

This possibly arises from the generally greater size of these other species relative to the killifish. However, there were no patterns found when comparing fish size and mean muscle tissue concentrations in these other species.

Geographical influences on mercury concentration within the higher order fish tend to agree with the geographical results on killifish. Although the sampling stations were few in number, those stations closest to Newark Bay or the mouth of the Hackensack River had the highest mean mercury values, while those stations in the north east sector of the sampling area yielded fish with the lowest values.

Differences in mercury contamination within the muscle, liver, and kidney tissues of the higher order fish were fairly irratic. In the majority of specimensthe muscle and liver mercury concentrations were comparable although in some samples mercury was somewhat higher in the liver than in muscle. Mercury concentrations in kidney tissue tended to be considerably lower than both liver and muscle, however, in some cases kidney tissue exhibited the highest concentration. With respect to mercury levels exceeding the original FDA standard, 48% of the liver samples, 37% of the muscle samples and 22% of the kidney samples exceeded 0.5 ppm of mercury.

Among the aquatic invertebrates, 28 fiddler crabs (Uca sp.), 10 blue claw crabs (Callinectes sapidus), and 54 grass shrimp (Palaeomonetes vulgaris) were collected at 11 sampling stations in the Meadowlands (Figure 2.). Tissues from these organisms yielded 148 mercury analyses. Among the fiddler crabs, muscle tissue, viscera and carapace of each specimen was analyzed. Frequency distribution and mean tissue concentrationsof mercury at each of the five collection stations are given in Tables 8. through 10. Greater mean concentrations consistently were observed at station 2 (Berrys Creek Canal) for each tissue type. At the other locations, mean values for each tissue type were observed to be lower at the upstream locations than the downstream locations. Also obvious in the data is the substantial difference in the levels of contamination of the three tissue types at all stations. Levels of mercury were observed in increasing concentrations in the carapace (0% above 0.5 ppm), muscle (4% above 0.5 ppm), and viscera (41% above 0.5 ppm). The data for Whole grass shrimp is arranged in a frequency distribution by station in Table 12. Concentrations ranged from .000 ppm to .517 ppm, with 98% of the analyses found to be below 0.5 ppm.

No comparisons were made for any of the other invertebrate species with regard to relative mercury at different stations since the data for these other species were too limited. However, the mercury levels from the muscle of the more abundent blue claw crab have been tabulated. Table 11. shows a frequency distribution of blue claw crab muscle. Concentrations ranged from .107 to .761 ppm in muscle tissue with 10 % of the analyses resulting in concentrations above 0.5 ppm.

Also collected and analyzed were a mud crab (Eurypanopeus depressus or Panopeus herbstii) and a very young common soft shell clam (Mya arenaria). Each, analyzed whole, yielded concentrations of .321 ppm and .697 ppm, respectively.

Discussion

The data for total mercury in fish of the Hackensack Meadowlands compared favorably with data from other areas (Bache, 1971; Barber, et al.,1972; Westoo, 1973; Lloyd, et al., 1977; Cutshall, et al., 1978; Hattula, et al., 1978) The range for muscle tissue concentrations from the 14 species analyzed was .000 to 1.877 ppm wet weight. However, the data suggests less environmental contamination than might be expected for fish in contaminated waters.

A relationship is observed between mercury concentrations in killifish muscle tissue and fish length. It may be assumed that size is representative of age of a fish (Barber, et al., 1972; Westoo, 1973; Cutshall, et al., 1978; Hattula, et al., 1978). Numerous studies have established that the total mercury concentration increases with age, although the accumulation rate decreases with size (Bache, et al., 1971; Barber, et al., 1972; Westoo, 1973; Cutshall, et al., 1978; Hattula, et al., 1978). This increase with age, as defined by size, may be exhibited by killifish of the Hackensack Meadowlands.

The measure of difference observed between liver and kidney tissue concentrations in the fishes is not observed in other vertebrate organisms of the Hackensack Meadowlands (Galluzzi, 1979). The pattern of higher levels in liver than muscle tissue compares favorably with data from other studies of mercury concentrations in fish tissues (Lloyd, et al., 1977; Gardner, et al., 1978).

Fiddler crabs exhibited elevated mercury concentrations characteristic of contaminated areas (Gardner, 1978). It was predictable that the highest mean values for all tissue types were observed in specimens from Station 2, closest to the former mercury processing plant. Because fiddler crabs are relatively territorial organisms, they may be a good indicator of environmental conditions within their surroundings.

Summary and Conclusions

1) Fish and invertebrates in the Meadowlands District exhibit higher mercury contamination relative to background levels. This contamination is not as high as one might expect given the high concentrations of the sediments in the area.

These lower than expected mercury values, observed in the fish, may be attributed to biologically inactive forms of mercury in the environment. Also, migratory patterns of the fish, length of time spent in specific areas, and breeding and feeding patterns have not been entirely considered. Additionally, no information concerning typical population densities and diversity in the Hackensack estuary is available. Such analyses would require good baseline data previous to contamination.

2) The fish data, particularly killifish, suggest that larger and/or older fish have greater concentrations of mercury.

3) The highest levels of fish contamination were observed to be at the stations in the southern portion of the sampling area - closest to Newark Bay, while the least contaminated organisms were observed to be primarily from the northeast section of the sampling area. The distribution pattern may reflect the salinity gradient which may effect the uptake and concentration of mercury by organisms in different sections of the estuary (Weis, 1978).

4) Fiddler crabs are a good environmental indicator for mercury contamination due to their relatively territorial nature.

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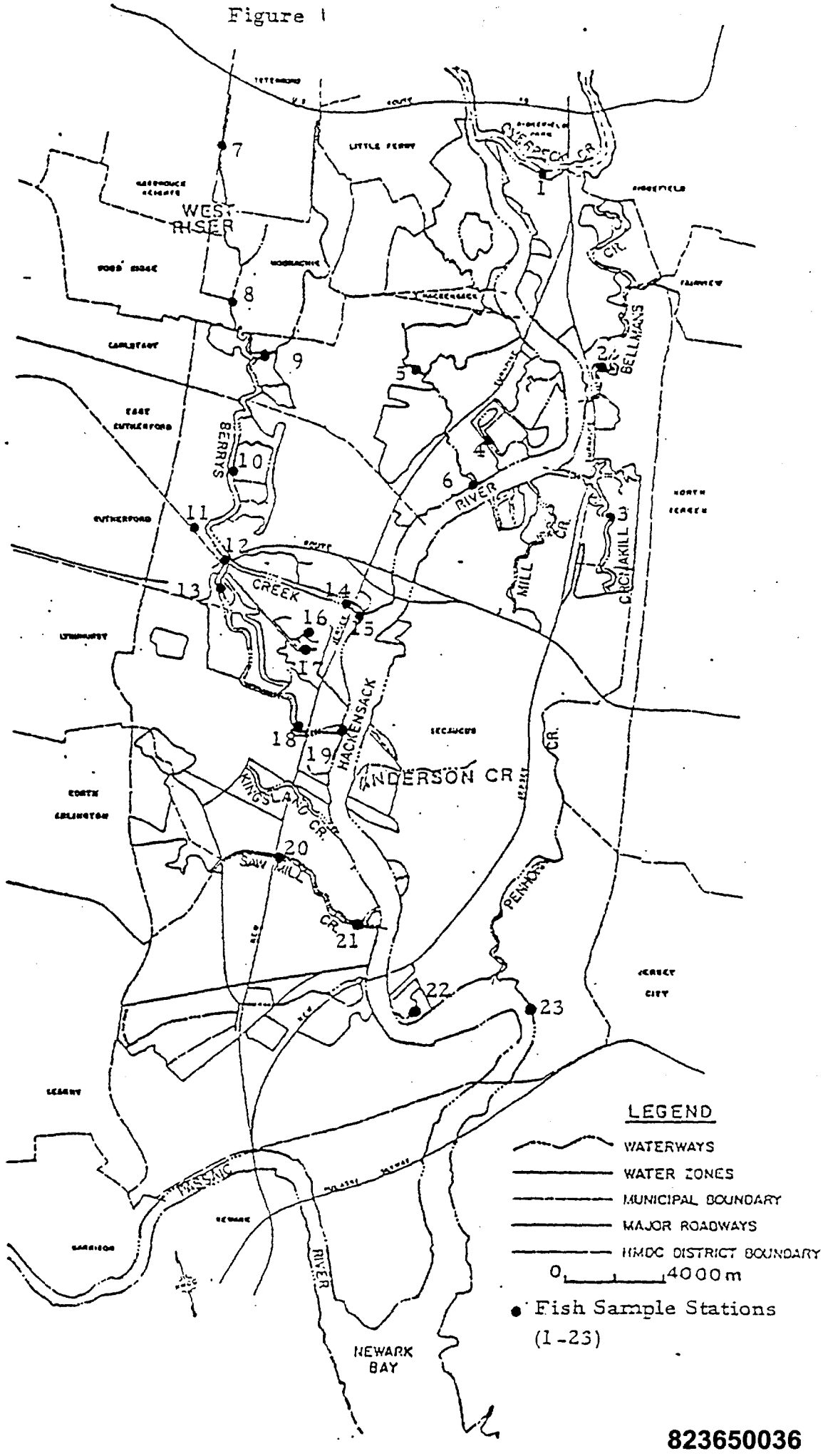
Figure 1



Figure

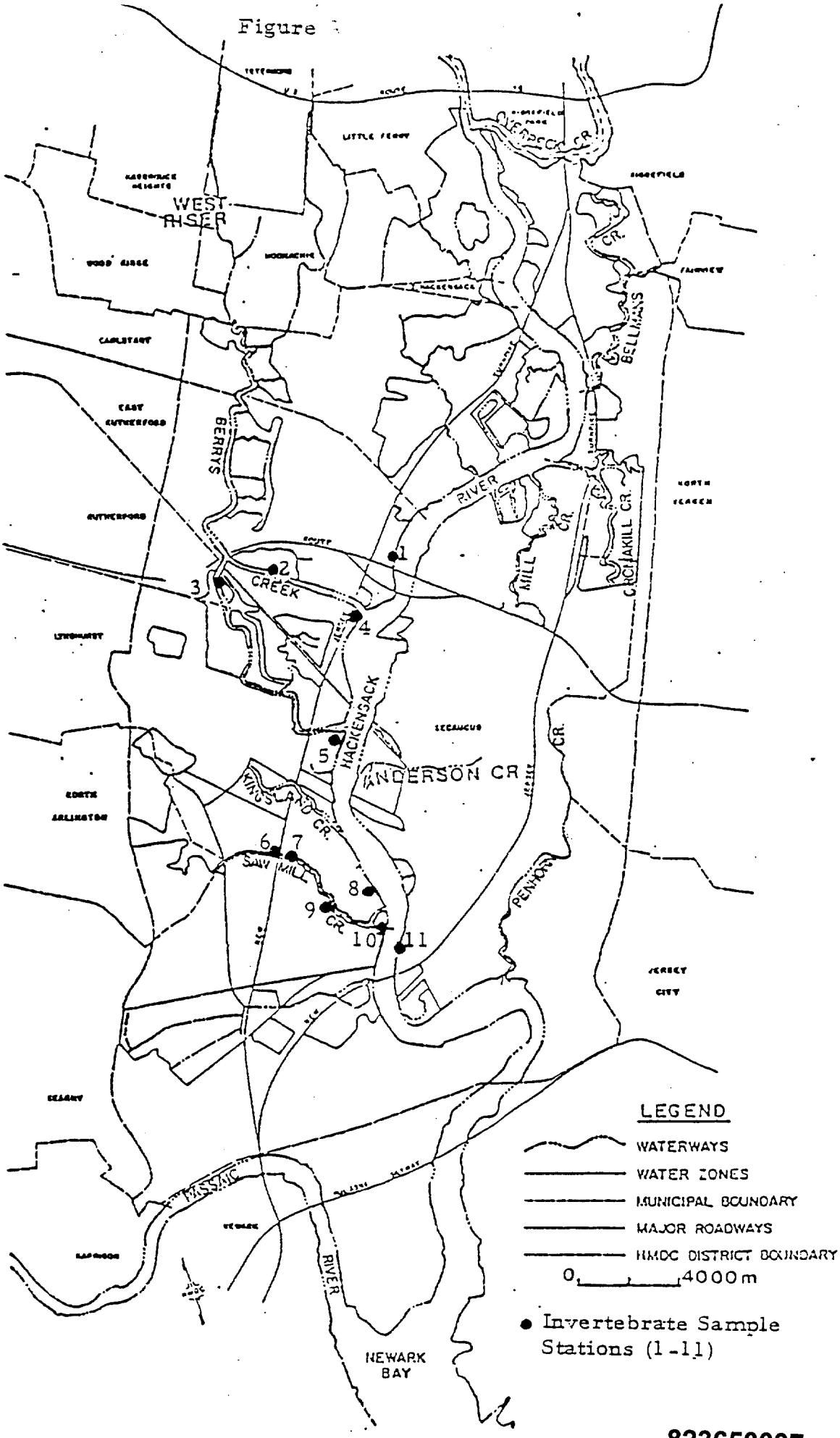


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Fig. 3

Killifish (Fundulus sp.) Muscle Tissue

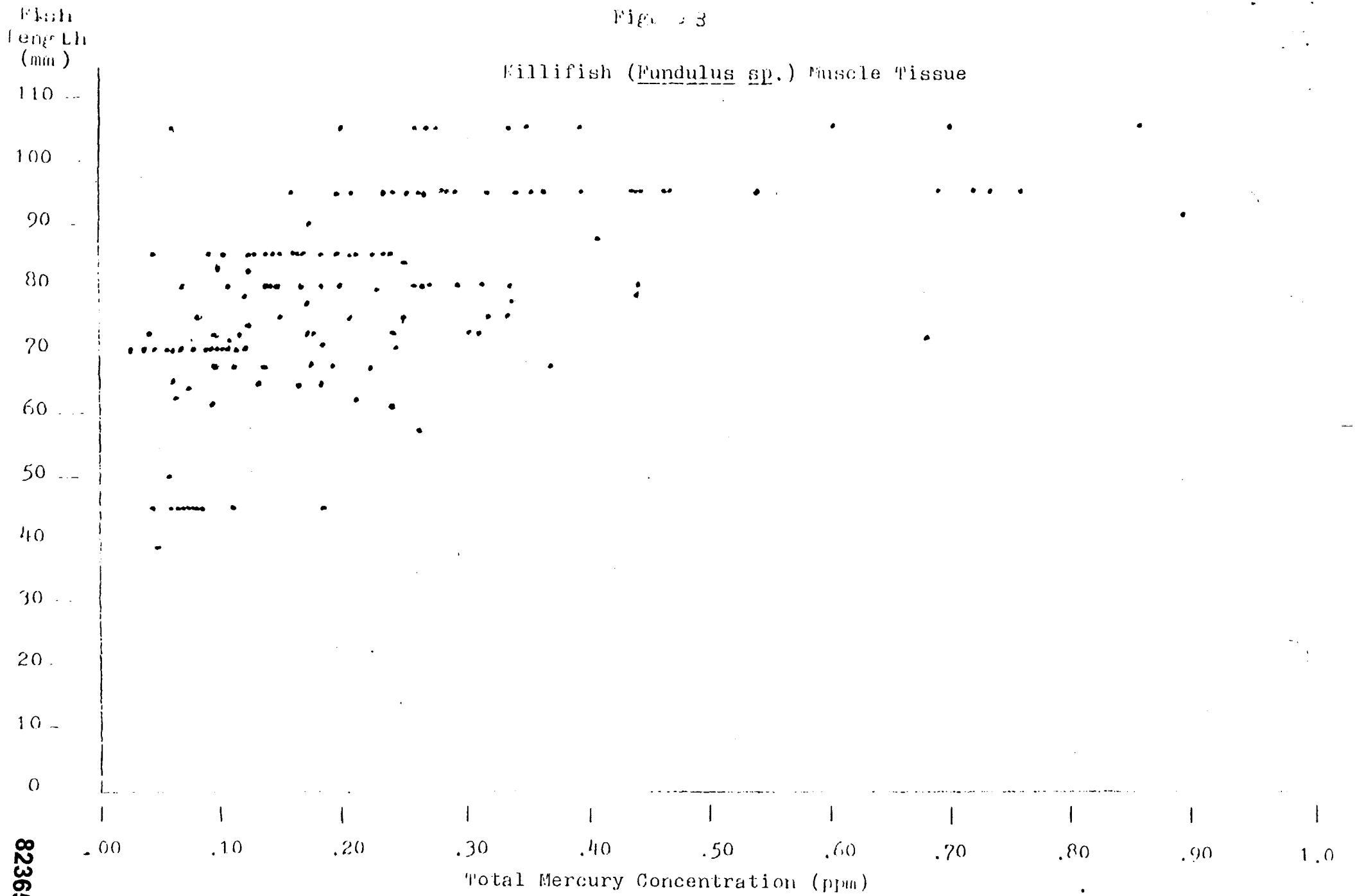

Table 1. Muscle Tissue

SPECIES	# OF SAMPLES	(concentration ppm) <0.1	0.1-0.5	0.5-1.0	>1.0	RANGE	$\bar{x}$
Killifish	159	36	113	10		.000-.368	.222
Carp	9	1	7	1		.052-.528	.261
White Perch	9		3	5	1	.275-1.877	.736
Alewife	7	1	2	4		.071-.806	.501
Bluegill Sunfish	5	4	1			.031-.122	.061
Blueback Herring	5			1	4	.781-1.712	1.269
Weakfish	5		2	2	1	.441-1.032	.681
American Eel	2		1	1		.264-.540	.402
Bluefish	1			1			.720
Pumpkinseed	2		2			.206-.231	.218
Common Anchovy	1			1			.708
Atlantic Silverside	1			1			.572
American Shad	1				1		1.692
Striped Sea Robin	1		1				.152
TOTAL ANALYSIS	208	42	132	27	7	.000-1.877	.451
TOTAL # OF FISH	479	112	325	35	7		
% OF FISH SPECIMENS	100	23	68	8	1		

Table a. Liver Tissue

SPECIES	# OF SAMPLES	(concentration ppm) <0.1	0.1-0.5	0.5-1.0	>1.0	RANGE	$\bar{x}$
Killifish							
Carp	7		6		1	.110-1.154	.450
White Perch	7		2	3	2	.249-1.385	.702
Alewife	1	1					.058
Bluegill Sunfish	1		1				.203
Blueback Herring							
Weakfish	5				5	1.141-2.081	1.700
American Eel	2		1		1	.116-3.763	1.940
Bluefish	1				1		1.141
Pumpkinseed	2		2			.206-.231	.219
Common Anchovy							
Atlantic Silverside							
American Shad							
Striped Sea Robin	1		1				.120
TOTAL ANALYSIS	27	1	13	3	10	.058-3.763	.566
TOTAL # OF FISH	27	1	13	3	10		
% OF FISH SPECIMENS	100	4	48	11	37		

Table 3. Kidney Tissue

SPECIES	# OF SAMPLES	(concentration ppm) <0.1	0.1-0.5	0.5-1.0	>1.0	RANGE	$\bar{X}$
Killifish							
Carp	8	5	3			.011-.440	.127
White Perch	7	4	3			.005-.386	.161
Alewife							
Bluegill Sunfish							
Blueback Herring							
Weakfish	5	1			4	.000-3.173	2.081
American Eel	1		1				.441
Bluefish	1				1		3.017
Pumpkinseed							
Common Anchovy							
Atlantic Silverside							
American Shad							
Striped Sea Robin	1	1					000
TOTAL ANALYSIS	23	11	7		5	.000-3.173	.696
TOTAL # OF FISH	23	11	7		5		
% OF FISH SPECIMENS	100	48	30		22		

Table 4. Killifish (Fundulus sp.) Muscle Tissue

STATION	# OF SAMPLES	(concentration ppm) <0.1	0.1-0.5	0.5-1.0	>1.0	RANGE	$\bar{X}$
1							
2	5	5				.035-.099	.070
3	8	2	6			.055-.175	.111
4	20	9	11			.025-.216	.109
5	4	2	2			.068-.129	.077
6							
7	10	8	2			.042-.183	.085
8	10	1	8	1		.077-.678	.242
9	10	1	9			.098-.370	.164
10	10	1	9			.060-.252	.187
11	4		4			.150-.411	.252
12	2		2			.239-.261	.250
13	9	2	7			.000-.382	.243
14	15	1	14			.070-.444	.214
15	2		2			.272-.354	.313
16	4		4			.119-.173	.139
17	1	1					.093
18	10		8	2		.198-.735	.352
19	2	2				.011-.019	.015
20	12		11	1		.132-.542	.315
21	10	1	7	2		.066-.865	.363
22	11		7	4		.307-.898	.520
23							
TOTAL ANALYSIS	159	36	113	10		.000-.898	.222
TOTAL # OF FISH	408	90	300	18			
% OF FISH SPECIMENS	100	22	74	4			

STATION	# OF SAMPLES	(concentration ppm) <0.1	0.1-0.5	0.5-1.0	>1.0	RANGE	$\bar{X}$
1	7	1	6			.071-.275	.127
2							
3							
4							
5	4	4				.051-.085	.057
6	6		5	1		.125-.528	.286
7							
8							
9							
10							
11							
12							
13	1			1			.540
14	5		2	2	1	.372-1.877	.796
15							
16							
17							
18							
19							
20	5		2	3		.269-.950	.590
21	1	1					.052
22							
23	20		4	10	6	.157-1.712	.840
TOTAL ANALYSIS	49	6	19	17	7	.051-1.877	.563
TOTAL # OF FISH	65	22	19	17	7		
% OF FISH SPECIMENS	100	34	29	26	11		

Table 6. Higher Order Fish Liver Tissue

STATION	# OF SAMPLES	(concentration ppm) <0.1	0.1-0.5	0.5-1.0	>1.0	RANGE	$\bar{X}$
1	6	1	5			.058-.249	.123
2							
3							
4							
5							
6	6		5		1	.110-1.154	.433
7							
8							
9							
10							
11							
12							
13	1				1		3.763
14	3		1	2		.490-.919	.650
15							
16							
17							
18							
19							
20	4		1	1	2	.141-1.385	.894
21							
22							
23	7		1		6	.120-2.081	1.662
TOTAL ANALYSIS	27	1	13	3	10	.058-2.081	.840
TOTAL # OF FISH	27	1	13	3	10		
% OF FISH SPECIMENS	100	4	48	11	37		

Table 7. Higher Order Fish Kidney Tissue

STATION	# OF SAMPLES	(concentration ppm) <0.1	0.1-0.5	0.5-1.0	>1.0	RANGE	$\bar{x}$
1	1	1					.054
2							
3							
4							
5							
6	6	5	1			.011-.153	.077
7							
8							
9							
10							
11							
12							
13	1		1				.441
14	3	2	1			.005-.300	.108
15							
16							
17							
18							
19							
20	5	1	4			.023-.440	.262
21							
22							
23	7	2			5	.000-3.173	1.913
TOTAL ANALYSIS	23	11	7		5	.000-3.173	.689
TOTAL # OF FISH	23	11	7		5		
% OF FISH SPECIMENS	100	48	30		22		

Table 8. Fiddler Crab (Uca Sp.) Muscle Tissue

STATION	# OF SAMPLES	(concentration ppm) <0.1	0.1-0.5	0.5-1.0	>1.0	RANGE	$\bar{x}$
1	2	1	1			.079-.117	.098
2	5		5			.145-.473	.329
3							
4							
5	6	1	5			.058-.321	.175
6							
7							
8							
9	8	1	6	1		.000-.532	.226
10	7		7			.177-.334	.270
11							
TOTAL ANALYSIS	28	3	24	1		.000-.532	.231
TOTAL # OF CRABS	28	3	24	1			
% OF CRAB SPECIMENS	100	11	86	4			

Table 9. Fiddler Crab (Uca Sp.) Viscera

STATION	# OF SAMPLES	(concentration ppm) <0.1	0.1-0.5	0.5-1.0	>1.0	RANGE	X
1	2		2			.148-.356	.252
2	5			3	2	.532-2.743	1.000
3							
4							
5	7		2	4	1	.383-1.172	.507
6							
7							
8							
9	8	2	4	2		.000-.599	.333
10	7		7			.116-.360	.210
11							
TOTAL ANALYSIS	29	2	15	9	3	.000-2.743	.543
TOTAL # OF CRABS	29	2	15	9	3		
% OF CRAB SPECIMENS	100	7	52	31	10		

Table 10. Fiddler Crab (Uca sp.) Carapace

STATION	# OF SAMPLES	(concentration ppm) <0.1	0.1-0.5	0.5-1.0	>1.0	RANGE	X
1	2	2					.000
2	5		5			.104-.366	.200
3							
4							
5	5	5				.028-.075	.044
6							
7							
8							
9	8	8				.000-.021	.003
10	7	7				.000-.040	.010
11							
TOTAL ANALYSIS	27	22	5			.000-.366	.010
TOTAL # OF CRABS	27	22	5				
% OF CRAB SPECIMENS	100	81	18				

Table 11. Blue Claw Crab (Callinectes sapidus) Muscle Tissue

STATION	# OF SAMPLES	(concentration ppm) <0.1	0.1-0.5	0.5-1.0	>1.0	RANGE	$\bar{X}$
1							
2							
3							
4							
5							
6	8		7	1		.107-.761	.233
7							
8							
9							
10							
11	2		2			.287-.378	.332
TOTAL ANALYSIS	10		9	1		.107-.761	.253
TOTAL # OF CRABS	10		9	1			
% OF CRAB SPECIMENS	100		90	10			

Table 12. Grass Shrimp (Palaemonetes vulgaris) Whole

STATION	# OF SAMPLES	(concentration ppm) <0.1	0.1-0.5	0.5-1.0	>1.0	RANGE	$\bar{X}$
1							
2							
3	6	2	3	1		.000-.517	.245
4	5	3	2			.000-.119	.070
5							
6							
7	37		37			.152-.413	.249
8							
9							
10							
11							
TOTAL ANALYSIS	48	5	42	1		.000-.517	.234
TOTAL # OF SHRIMP	54	5	48	1			
% OF SHRIMP SPECIMENS	100	9	89	2			

MERCURY CONCENTRATIONS IN MAMMALS, REPTILES BIRDS, AND WATERFOWL COLLECTED IN THE HACKENSACK MEADOWLANDS, NEW JERSEY

ID 11

Report_Number 1981-001

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Presented At: The New Jersey Academy of Sciences
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ABSTRACT

Concentrations of mercury were determined in various tissues of 6 reptiles, 36 mammals comprising eight species, and 35 specimens of birds and waterfowl. Analysis was done by cold vapor absorption spectrophotometry following acid digestion of the tissues in the laboratory of the Hackensack Meadowlands Development Commission. Although a distinct gradient of mercury contamination in marsh sediments exists within the Meadowlands, no geographic pattern of contamination was observed among the biota. Concentrations among the mammals ranged from 0 to 4.0 ppm with decreasing concentrations observed in the kidney, fur, liver, and muscle tissues. Among the birds and waterfowl, decreasing concentrations were observed in feather, kidney, liver, and muscle tissues with a high concentration of 9.0 ppm observed in the feathers of a Green Heron. Variations in concentrations among species occur as a result of the trophic level and food preferences with which the species are associated.

INTRODUCTION

Public attention to contamination of mercury in the Hackensack Meadowlands first arose during 1972 when high concentrations were found in Berrys Creek tidal marsh, also known locally as Walden Swamp, adjacent to the New Jersey Sports Complex (Figure 1). In a study for the environmental impact assessment of the then proposed Sports Complex, unusually high concentrations of mercury were found in marsh and channel sediments (McCormick and Associates, 1972). Repeated measurements within Berrys Creek tidal marsh in 1974 confirmed the 1972 data and led to further investigations by others (Galluzzi, 1976; McCormick, 1976; NJDEP, 1977). National attention focused on the issue of mercury contamination in the

Meadowlands in 1979, when the State of New Jersey brought legal action in Superior Court against the chemical firms alleged to have discharged mercury into Berrys Creek, a tidal tributary to the Hackensack River, for over 30 years (New York Times, 1979). Although the court case was decided against the defendants, clean-up strategies for Berrys Creek still must be argued before the court in appeals hearings.

Concentrations of mercury in sediments collected from the Berrys Creek Basin during the present investigation, ranged from <0.1 to 2006 ppm in samples. (Galluzzi and Sabounjian,1980). The highest concentration previously reported (264 ppm) was observed in the marsh sediments of Berrys Creek Tidal Marsh (McCormick,1974). Hence, high concentrations were expected to be found in the various tissues of wildlife inhabiting the marshes of the Meadowlands, especially those in or adjacent to the Berrys Creek Basin. Prior to this investigation, mercury concentrations ranging from 0.13 ppm to 0.50 ppm were reported in blue claw crabs (Calinectes sapides) collected from Sawmill Creek between 1973 and 1976. (NJDEP,1976). Sawmill Creek is a tidal tributary of the Hackensack River almost seven miles (10.6 km) downstream from the mercury discharge site on Berrys Creek (Figure 1). During 1976, average concentrations of mercury in whole killifish (Fundulus sp.) collected from Berrys Creek were found to range from 0.7 ppm to 1.9 ppm (Jack McCormick & Associates, 1976). As part of the present investigation, Sabounjian and Galluzzi (1980) reported concentrations ranging from 0.0 to 3.8 ppm in various tissues of fish and aquatic invertebrates collected within the estuary. The highest concentration of mercury observed among six tissues of muskrats (Ondatra zibethicus) collected from Berrys Creek tidal marshes, and compared with muskrats collected from other marshes within the estuary, was found in kidney tissue (1.2 ppm) Galluzzi, 1976). Levels of mercury in the muscle tissue of various mammals collected from the upper Berrys Creek basin, among them muskrat, oppossum, raccoon, skunk and rabbit, ranged from <0.07 ppm to 0.2 ppm (NJDEP, 1977). In this latter study, two pheasants from Berrys Creek tidal marsh each had muscle tissue concentrations of 0.07 ppm. The present study was intended as the first large sampling of vertebrates from the Hackensack Estuary and is meant to provide a data base for future studies of mercury d other heavy metals.

METHODS AND MATERIALS

All biological specimens were placed in tightly sealed plastic bags and frozen prior to analysis. Procedures for the cold vapor determination of mercury followed Uthe, et al, 1970; Perkin Elmer, 1971; Koch and Manning, 1973; and Beaty, 1978. Tissue preparation and analysis were performed from April through November 1978. Aliquots of selected tissues ranging between 0.5 and 1.0 grams were weighed to the nearest 0.1 mg on an analytical balance. The only modification to the analytical procedures outlined by those above was the utilization of an 8 ounce (236 ml) sample preparation bottle as a reduction chamber for the acid digested and oxidized sample. In this manner, no transfer of sample was required, thereby eliminating a potential loss of mercury during the analytical procedure. Mercury determinations were performed on an atomic absorption spectrophotometer (Perkin Elmer, Model 272) equipped with a hollow cathode mercury lamp and a quartz-glass flow through cell. Concentrations were determined from absorption units read from the spectrophotometer digital display and permanently retained on a chart recorder (Perkin Elmer, Model (023). Calibration curves were prepared for each sample batch with newly prepared standards from a stock 1000 ppm mercury solution. Additionally, two reagent blanks, containing the digestion reagents and prepared in the same manner as the samples, were run with each group of tissue samples. The average absorption response value of the two reagent blanks was subtracted from the response value of each sample in order to eliminate background or introduced mercury contamination. Quality assurance procedures during the study included random duplicate analyses, split sample analyses by laboratories at the New Jersey Department of Health and the New Jersey Institute of Technology, and analyses of reference samples

obtained from the United States Environmental Protection Agency.

Location Of Collection Sites

Several factors affected the selection of sites for the collection of specimens. Most obviously, specimens were desired from areas within the Berrys Creek Basin owing to the likelihood that the greatest degree of contamination in the biota would occur in the areas of greatest environmental contamination. However, the ecological biozone with which a given specimen was associated was not always to be found within the Berrys Creek Basin. Food preferences, availability of preferred habitat, and ultimately the environmental quality of a site upon which the food web of a given specimen depended all played a role in choosing sites for collection. In several instances, especially with regard to the collection of waterfowl, collection sites would not necessarily denote a specific geographical area of the Meadowlands with which a given specimen could be exclusively associated. Efforts were made to collect organisms from areas of the Meadowlands that were geographically removed from the highly contaminated Berrys Creek Basin as well as those areas known to support the greatest variety and numbers of estuarine wildlife.

RESULTS

Mammals

Thirty-six mammals, comprising eight species, were collected from 16 locations within the Hackensack Meadowlands during 1978. Concentrations of mercury were determined in fur, muscle, liver, and kidney tissues. Blood and fat tissue from a skunk (Mephitis mephitis) and a raccoon (Procyon lotor), collected from the West Riser Ditch of Berrys Creek, also were analyzed (Table 1). Among the mammals, the highest concentration, 4.0 parts per million (ppm) was observed in the fur of a Norway rat (Rattus norvegicus) collected just south of Berrys

Creek Canal and west of the New Jersey Turnpike. No mercury was detected in four of 27 fur samples, 22 of 35 muscle tissue samples, 12 of 35 liver tissue samples, 4 of 34 kidney tissue samples, or 1 of 2 fat tissue samples.

Analyses for mercury also were performed on tissues of four mammals collected outside of the Meadowlands District (Table 1). These included a raccoon, from Oakland, N. J., a beaver (Castor canadensis) from Sussex County, N. J., and two muskrats (Ondatra zibethicus), one from Sussex County and one from Monmouth County, N. J. Concentrations of mercury in tissues from these mammals ranged from .006 ppm, in liver tissue from the Sussex County muskrat, to .248 ppm, in liver tissue from the raccoon.

No geographical pattern or gradient of contamination could be determined from the data among the 36 specimens collected within the Meadowlands District. However, marked differences in the concentrations of mercury in each tissue type were observed consistently among the specimens, at each of the collection sites. Frequency distributions of mercury concentrations in each of the tissues are given in Tables 2 through 5. Decreasing average concentrations were observed in the kidney, fur, liver, and muscle tissues.

A comparison of the mammalian tissue concentrations with the previous "maximum allowable guideline" of 0.5 ppm in foodstuffs, promulgated by the United States Food and Drug Administration, and the current guideline of 1.0 ppm is given below:

1. Concentrations of mercury in muscle tissue were less than 0.5 ppm in each of the 35 specimens analyzed.
2. Among the liver tissue samples, 33 of 35 were less than 0.5 ppm, and only one was greater than 1.0 ppm.
3. Ten of 27 fur sample concentrations were greater than 0.5 ppm and, of these, five were greater than 1.0 ppm.
4. Among the samples of kidney tissue, ten of 34 were greater

than 0.5 ppm and of these, four were greater than 1.0 ppm.

Reptiles

Two diamond-back terrapins (Malaclemys terrapin) and four snakes were collected and analyzed for mercury during 1978. The terrapins were collected in submerged hoop nets in the Sawmill Creek Wildlife Management Area. Both specimens were females about seven and ten years of age, respectively. Dissection of the stomach and alimentary canal yielded mud crabs, exclusively, in various stages of digestion. Both specimens were considerably contaminated with mercury. The observed tissue concentrations (Table 6) in decreasing order were: liver, 7.6 and 3.6 ppm; kidney, 2.4 and 1.1 ppm; muscle, .996 and .524 ppm; and, skin, .261 and .139 ppm. Additionally, egg material from each specimen was analyzed. Concentrations less than 0.1 ppm were observed in both egg and egg shell. An analysis of blood from one of the specimens yielded a concentration of .151 ppm mercury.

The four snakes collected during the study were three garter snakes (Thamnophis sintalis) collected from Losen Slote Creek, Penhorn Creek, and Windy Ditch; and one milk snake (Lampropeltis doliata) collected from Losen Slote Creek (Figure 1). Skin, muscle, liver, and kidney tissues were analyzed. Concentrations of mercury in the milk and garter snakes collected from Losen Slote Creek were low, ranging from 0.0 ppm in skin and kidney tissue to .247 ppm in liver tissue. Concentrations observed in the two garter snakes collected from the lower river tributaries were much greater. The concentrations observed were: .118 and .637 ppm in muscle tissue; .730 and 3.2 ppm in liver tissue; .848 and .114 ppm in kidney tissue; and, .100 and .882 ppm in skin tissue from the Penhorn Creek and Windy Ditch snakes, respectively.

The concentrations of mercury accumulated in the various tissues were greatest in liver tissue among five of the six reptiles collected within the Meadowlands District.

Birds and Waterfowl

Thirty-five specimens of birds and waterfowl were collected at 16 locations within the Meadowlands District. Mercury analyses were performed on four tissues: feather, muscle, liver, and kidney, yielding a total of 139 analyses (Table 7). Mercury was found in every tissue analyzed. The highest tissue concentration of mercury was found in the feathers of a Green Heron (9.0 ppm) collected in the Sawmill Creek Wildlife Management Area. Concentrations observed in the feathers well exceeded those found in other tissues among 31 of 33 specimens compared and, generally, were at least three times as great. Average tissue concentrations of mercury, in decreasing order, were observed as follows: feather (3.2 ppm), kidney (1.1 ppm), liver (1.1 ppm), and muscle (.358 ppm). There were not enough specimens collected at each station nor were there enough specimens of the same species for statistical analyses for significance to be performed. Consequently, no geographical patterns could be determined from station to station or even between the upper and lower estuary.

DISCUSSION

Tissue concentrations of mercury in the mammals and birds collected in the Hackensack Meadowlands compare favorably with levels observed in terrestrial herbivores and omnivores (Cumbie and Jenkins, 1974; Borg, et al., 1969). Generally, lower values were observed than those reported in most other studies of mercury contamination in various wildlife environments. Concentrations in California Sea Lions from the Oregon Coast averaged 1.41 ppm in muscle tissue, 3.7 in kidney tissue, and an astounding 137 ppm in liver tissue (Buhler & Mate, 1973). In fur seals collected in Alaska and off the coast of Washington, mercury levels in muscle tissue averaged from 0.06 ppm in pups to 0.26 ppm in adult females (Anas, 1973). In Sweden, Borg, et al. (1969) observed concentrations as high as 21 ppm in mixed liver and kidney tissue of field mice. In

the southeastern United States, Cumbie Jenkins (1974) reported average concentrations in raccoons ranging from 0.13 to 0.39 ppm in skeletal muscle and 1.43 to 4.53 ppm in liver tissue.

Concentrations of mercury in mammals from the Meadowlands indicate a very slight contamination in comparison to other studies. Huckabee, et al. (1973) reported that concentrations of 0.6 ppm or higher are indicative of environmental contamination. The frequency distribution of mercury concentrations in the various tissues (Tables 2 through 5) indicate, as suggested by others, that deposition of mercury is occurring in the kidney and fur of mammals. These sites of deposition probably result from body burden detoxification by the kidney and an export mechanism by the fur, similar to that found in feathers of birds. Liver tissue also has been shown to be a specific site for mercury accumulation as evinced in the reptiles and birds. Gardner, et al. (1978) in studies of methyl mercury contamination in salt marsh ecosystems, found a correlation between elevated concentrations in muscle tissue and those observed in liver tissue. However, they also noted that whereas methyl mercury is retained in muscle tissue, other forms of the metal tends to accumulate in the livers and kidneys and are probably excreted over time. Within the salt marsh system, higher trophic level organisms exhibit mercury mainly as methyl mercury. Sediments, plants, and primary consumers contain very low, but measurable concentrations of methyl mercury. The form of mercury in the marsh ecosystem, then, becomes an important factor in the transfer of mercury up the food chain.

Among the birds and waterfowl, concentrations, generally, were greater in the aquatic birds than those restricted to a terrestrial habitat. This would indicate that the movement and transport of mercury throughout the Meadowlands ecosystem occurs primarily in the water environment. Hence, those species most contaminated by mercury will be those who depend directly on the aquatic foodweb. Variations in concentrations among these species will occur as a result of the

trophic level and feeding preferences with which the species are associated. The degree of dependency on the aquatic foodweb is not necessarily the primary indicator of probable contamination as is the feeding behavior in the aquatic ecosystem. This is especially evinced in the levels of contamination found in the herons as compared with those in the ducks, gallinules and gulls (Table 8). In that the herons feed exclusively on aquatic animal life (mollusks, crustaceans, amphibians, and small fish), the levels of contamination are higher than the ducks and gallinules which are more seasonal in their carnivorous feeding behavior and include vegetation as a major part of their diet. Diving ducks and shorebirds which sieve and pick through bottom sediment as part of their feeding behavior, most likely could be expected to absorb higher concentrations of mercury, although predominantly in an inorganic form, directly from the sediment as well as from their food resources. Although surface feeders and skimmers, in light of the above, would be expected to absorb less mercury from sources outside their food resource, the importance of the water surface microlayer as a transport mechanism cannot be ignored. Lion, et al. (1979) observed an accumulation in the surface microlayer of vegetative particulates, nutrients, and metals in significantly greater concentrations than those observed in bulk water analyses.

Levels of contamination in tissues of terrestrial birds was significantly lower than those of the aquatic birds. If mercury is being transported within the terrestrial environment, it is being done at a very slow rate. Most likely, only a small percentage of the mercury is in a form which is available for movement in the terrestrial ecosystem. Wood et al. (1977) showed that in the aquatic system the rate of conversion of mercury to an organic form is a relatively slow one. However, once in a form available for biological uptake, mercury compounds will readily and very quickly pass through cell membranes. And so, as in the aquatic environment, it probably is the initial conversion

process to an available form that is the rate limiting step for the movement of mercury in the terrestrial environment.

Instantly obvious is the substantial difference of levels of contamination in the various tissues analyzed. Levels of mercury were found in decreasing concentrations in the feather (3.2 ppm), kidney (1.1 ppm), liver (1.1 ppm), and muscle (.358 ppm) tissues (Table 9). Generally, the amount of mercury observed in feathers was three times that found in any other tissue. The bonding properties of mercury have been observed to be more affinitive to proteinaceous bonds than those of other biochemical compounds. The uptake and deposition of mercury in feather tissue can be easily interpreted when the high protein content of feather tissue is realized. In fact, it is the deposition of proteinaceous mercury that effectuates the feathers to become the chief export mechanism for mercury in birds. The periodic shedding and loss of plumage makes way for renewed deposition during growth of new feathers. The uptake of mercury by tissues of the liver and kidney is an expected biological occurrence in that, these are the cleansing organs of the body by which contaminants and toxic metabolic wastes are removed. It can be anticipated that levels of mercury in these organs would be higher than those in other tissues. The concentrations found in these organs of the Meadowlands waterfowl are indicative of environmental contamination. The absence of such high levels in the musculature of the specimens, however, gives credibility to the notion that the mercury is not in a biologically active form.

The concentrations of mercury observed in the tissues of birds and waterfowl from the Meadowlands do not nearly reflect the severe contamination known to exist in the sediments. In fact, the observed concentrations do not differ greatly from random investigations of game birds by others. In pheasants and game birds from Utah, Smith (1973) reported mercury concentrations in muscle tissue ranging from 0.01 to 0.53 ppm. In a similar study of game birds from

Washington, King and Lauckhardt (1973), reported mercury levels ranging from 0.006 to 0.766 ppm with one anomalous observation over 4.0 ppm in breast muscle tissue. Liver tissue concentrations ranged from 0.005 to 4.84 ppm. In an investigation of the effects of the use of organic mercury compounds as seed disinfectants in Sweden, Borg, et al. (1969) reported mixed liver and kidney tissue levels of mercury in 25 pheasants ranging from 0.2 to 2.0 ppm in 15 of them and levels between 2.0 and 20.0 ppm in the remaining ten. Among the birds of prey, concentrations in liver and kidney tissue ranged from 0.2 to 6.5 ppm among 29 buzzards and 0.2 to 53.0 ppm among 41 goshawks; 55 percent of the buzzards and 56 percent of the goshawks exhibited levels exceeding 2.0 ppm and 5.0 ppm, respectively. Heinz (1975) reported that mallard ducklings became hyper-responsive in approach and avoidance behavior when fed a diet containing 0.5 or 3.0 ppm mercury. Interferences with reproduction, expecially hatchability, from mercury contamination has been well documented (Borg, et al. 1969; Heinz, 1974). Levels of methyl mercury exceeding 0.6 ppm in the eggs of pheasants could be correlated with embryonic death. Notwithstanding, higher levels in mallard eggs, 2.7 ppm, have been reported by Dustman, et al. (1972) in the Lake St. Clair area. Also, a common turn egg and a herring gull egg were observed to contain 6.25 and 15.8 ppm, respectively Dustman, et al.(1972) and Vermeer, et al. (1973). Stendell, et al. (1977) reported concentrations less than 0.16 ppm in 34 canvas back duck eggs collected from North Atlantic Estuaries and the interior United States. Thus, tissue levels among the Hackensack Meadowlands specimens would not appear to induce severe stress to the birds or waterfowl from the existent mercury contamination.

Mercury levels among the reptiles, especially the diamond back terrapins, collected in the Sawmill Creek Wildlife Management Area, would appear to indicate the presence of considerable mercury contamination in their habitat and food resources. However, owing to the principal accumulation in the liver and kidney

and the significantly lower concentrations in the muscle tissue, it would appear that the form of mercury may well be predominantly inorganic. The remoteness of the collection sites of the four snakes from the severely contaminated Berrys Creek Basin and the terrestrial habitats in which they were collected, reduces the probability that tissue concentrations in these specimens could be resultant from aquatic dispersal of mercury from Berrys Creek. Most probably, these specimens accumulated mercury from nearby landfills and upland contamination.

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Members of the Hackensack Meadowlands Development Commission Environmental Programs and Planning staff were participants in this study and in the preparation of this report. They are: Elizabeth Leach Sabounjian, Donald Smith, Chester Mattson, Nicholas Vallario, Susan Anisfield, James Kocis, and Kathy Marinaro.

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TATION	SPECIES	FUR	MUSCLE	LIVER	KIDNEY	BLOOD	FAT
ittle Ferry esidential Area	Oppossum	--	.112	.581	1.7		
osen Slote Creek	Muskrat	--	0	.006	.050		
arlstadt omm/Industrial	Oppossum	--	.216	3.0	--		
ransco Road	House Mouse	0	0	0	0		
arlstadt	Vole	0	0	0	0		
est Riser Ditch	Raccoon	.747	.064	.162	.395	.010	0
	Skunk	.691	.060	.197	.268	--	.010
	Muskrat		.013	.095	.022		
unction of Berrys	House Mouse	.726	.045	.101	.092		
reek Canal & Creek,	House Mouse	.428	0	0	.926		
orth of railroad racks	House Mouse	.344	0	.113	0		
oute 3 South	Vole	.227	0	0	.250		
ervice Road	Voie	.316	0	0	.128		
	Rabbit	.085	0	.112	.522		
rea south of Rt.3	Rabbit	.045	0	.181	.730		
o.Service Rd.exit	Vole	.056	0	0	.310		
	Vole	.041	0	0	.134		
errys Creek	House Mouse	1.4	0	.013	.210		
ent Tract	House Mouse	.891	0	.098	.635		
	House Mouse	2.3	.029	.208	.519		
	House Mouse	.239	0	0	.888		
	House Mouse	0	0	0	.121		
outh of Berrys	House Mouse	.657	0	.080	.379		
reek Canal, east	House Mouse	0	0	0	0		
Transco Road,	Norway Rat	4.0	.045	.134	1.9		
est of Turnpike	Oppossum	1.9	.195	.224	1.9		
ergen County ndfill	Norway Rat	.365	0	.022	.125		
ransco Road ngsland Creek	Rabbit	.075	0	.147	.271		
awmill Creek	Muskrat	--	.005	.067	.006		
	Muskrat	--	.005	.059	.020		
arny Freshwater rsh	Muskrat	--	.013	.009	.042		
E&G Road	Norway Rat	.393	0	.013	.477		
arny	Vole	.250	0	0	.087		
	Vole (imm)		WHOLE				.30
	Vole	--	0	0	.206		
nhorn Creek	Norway Rat	3.4	.141	.256	2.4		
irlawn	Raccoon	--	.064	.248	.227	.012	
ssex County	Beaver	--	.026	.015	.061	.038	
	Muskrat	--	.012	.006	.047		

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TABLE 2 - Frequency Distribution of Concentrations of Mercury (ppm) In Muscle Tissues Of Mammals Collected In The Hackensack Meadowlands During 1978

SPECIES	NO. OF SAMPLES	<0.1	0.1 - 0.5	0.5 - 1.0	>1.0
House Mouse	11	11	0	0	0
Muskrat	5	5	0	0	0
Norway Rat	4	3	1	0	0
Oppossum	3	0	3	0	0
Rabbit	3	3	0	0	0
Raccoon	1	1	0	0	0
Skunk	1	1	0	0	0
Vole	7	7	0	0	0
TOTAL	35	31	4	0	0

TABLE 3 - Frequency Distribution of Concentrations of Mercury (ppm) in Liver Tissue of Mammals Collected in the Hackensack Meadowlands During 1978

SPECIES	NO. OF SAMPLES	<0.1	0.1 - 0.5	0.5 - 1.0	>1.0
House Mouse	11	8	3	0	0
Muskrat	5	5	0	0	0
Norway Rat	4	2	2	0	0
Oppossum	3	0	1	1	1
Rabbit	3	0	3	0	0
Raccoon	1	0	1	0	0
Skunk	1	0	1	0	0
Vole	7	7	0	0	0
TOTAL	35	22	11	1	1

TABLE 4 - Frequency Distribution of Concentrations of Mercury (ppm) in Fur of Mammals Collected in the Hackensack Meadowlands During 1978

PECIES	NO. OF SAMPLES	<0.1	0.1 - 0.5	0.5 - 1.0	>1.0
ouse Mouse	11	3	3	3	2
uskrat	0	0	0	0	0
orway Rat	4	0	2	0	2
ppossum	1	0	0	0	1
abbit	3	3	0	0	0
accoon	1	0	0	1	0
kur	1	0	0	1	0
ole	6	4	2	0	0
TOTAL	27	10	7	5	5

TABLE 5 - Frequency Distribution of Concentrations of Mercury (ppm) in Kidney Tissue of Mammals Collected in the Hackensack Meadowlands During 1978

SPECIES	NO. OF SAMPLES	<0.1	0.1 - 0.5	0.5 - 1.0	>1.0
House Mouse	11	4	3	4	0
Muskrat	5	5	0	0	0
Norway Rat	4	0	2	0	2
Oppossum	2	0	0	0	2
Rabbit	3	0	1	2	0
Raccoon	1	0	1	0	0
Sk'	1	0	1	0	0
Vole	7	3	4	0	0
TOTAL	34	12	12	6	4

E 6 - Concentrations of Mercury (PPM) in Tissues of Terrestrial Invertebrates and Reptiles Collected in the Hackensack Meadowlands

ON	SPECIES	MUSCLE	LIVER	KIDNEY	SKIN	EGG	EGGSHELL	WHOLE	BLOOD
's Creek Center	Cockroach							.076	
ıct	Slug							.144	
Rd.									
e Ferry	Garter Snake	.093	.247	.000	.000				
Slote Creek	Milk Snake	.012	.044	.027	.020				
ll Canal Ditch	Diamond Back Terrapin	.996	7.6	2.4	.261	.045			
ll Creek	Diamond Back Terrapin	.524	3.6	1.1	.139		.046		.151
rn Creek	Garter Snake	.118	.730	.848	.100				
Ditch	Garter Snake	.637	3.2	.114	.882				

ATION	SPECIES	FEATHER	MUSCLE	LIVER	KIDNEY	
th of Bellman's ek	Gallinule	1.5	.059	.559	.616	
lm s Creek	Great Blue Heron	2.4	.408	.426	.729	
en Slote Creek	Green Heron (imm)	4.3	.368	.830	.485	
hout Creek	Great Blue Heron	6.1	1.2	4.0	1.5	
	Gallinule	3.8	.417	1.4	2.6	
mer Ventron-site	Woodcock	.124	.263	.426	.819	
rys Creek Tidal sh	Gallinule	4.4	.189	1.2	2.6	
rys Creek	Green Heron	.460	.852	3.1	2.9	
rys Creek Canal	Gallinule	5.8	.593	1.9	4.4	
h Creek near lroad Track	Pheasant	.438	.009	.059	.053	
npike Exit 16W	Barn Owl	--	.064	.075	.097	
y Ann Creek	Gallinule	5.5	.471	2.3	2.1	
mill Creek	Gallinule	6.2	.557	.939	1.6	
	Green Heron	9.0	.825	1.8	1.5	
	Snowy Egret	1.6	.399	1.0	.736	
	Coot	2.9	.521	--	.530	.13
	Black Crowned Night Heron	4.2	.098	1.3	1.8	.51
	Herring Gull	1.9	.674	.896	1.3	
	Laughing Gull	6.1	.239	.974	.974	
	Laughing Gull	3.5	.167	1.1	.593	
	Green Wing Teal	3.2	.070	.040	.083	
	Black Duck	2.0	.224	1.4	1.4	.09
	Lesser Scaup	4.1	.501	2.0	1.7	
	Mallard	.809	.182	.628	.639	
	Mallard	.894	.095	.635	.682	
	Mallard	2.5	.716	1.2	1.1	
	Mallard	7.5	.458	1.2	.620	
	Dowitcher	1.2	.238	.362	.389	
ndy Ditch	Gallinule	6.1	.298	1.1	1.4	
	Blue Wing Teal	1.9	.369	1.7	1.0	
	Mallard	2.3	.462	1.1	1.5	
leville Turnpike io Station	Coot	.310	.011	.194	.022	
le le Pike 2G	Herring Gull	1.8	.316	1.8	.027	
ony Freshwater sh	Gallinule	1.6	.105	.210	.277	
	Gallinule	--	.127	.446	--	

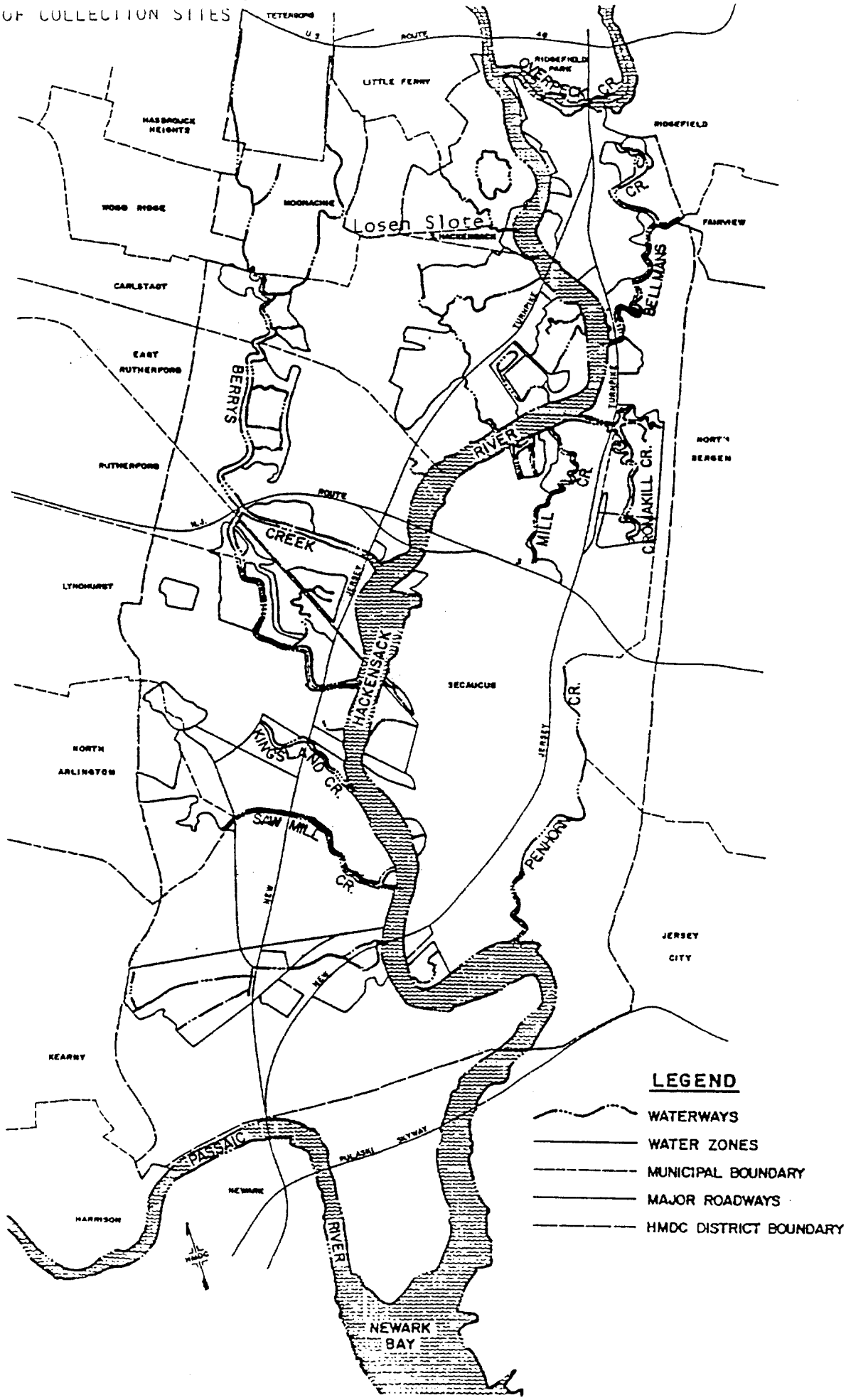
TABLE 8 - Average Concentrations of Mercury (ppm) in Tissues of Marsh Birds and Waterfowl, Arranged by Order and Family, Collected in the Hackensack Meadowlands During 1978

No.	Species	Feather	Muscle	Liver	Kidney
	Surface Feeding Ducks				
1	Green wing Teal	3.2	.070	.040	.088
1	Black Duck	2.0	.224	1.4	1.4
1	Blue wing Teal	1.9	.369	1.7	1.0
5	Mallard	2.8(±2.7)	.383(±.248)	.953(±.296)	.908(±.385)
	Bay Ducks				
1	Lesser Scaup	4.1	.501	2.0	1.7
	(Gallinules, Coots)				
9(*8)	Gallinule	4.4(±1.9)*	.313(±.204)	1.1(±.682)	1.9(±1.3)*
2(*1)	Coot	1.6	.266	.194*	.276
	Herons				
2	Great Blue Heron	4.2	.804	2.2	1.1
3	Green Heron	4.6	.682	1.9	1.6
1	Black Crowned Night Heron	4.2	.098	1.3	1.8
1	Snowy Egret	1.6	.399	1.0	.736
	Gulls				
2	Herring Gull	1.8	.495	1.3	.664
2	Laughing Gull	4.8	.203	1.0	.784
1	Dowitcher (Shorebird)	1.2	.238	.362	.389
1	Woodcock	.124	.263	.426	.819
1	Pheasant	.438	.009	.059	.053
1	Barn Owl	--	.064	.075	.097

TABLE 9 - Summary of Average Concentrations of Mercury (ppm) in Tissues of Marsh Birds and Waterfowl of the Hackensack Meadowlands, Arranged by Order

No.	Type	Feathers	Muscle	Liver	Kidney
9	Ducks	2.8	.342	1.1	.859
11(10*)	Gallinules/Coots	3.8*	.304	1.0*	1.6*
7	Herons	4.0	.593	1.8	1.4
4	Gulls	3.3	.349	1.2	.724
1	Dowitcher	1.2	.238	.362	.389
1	Woodcock	.124	.263	.426	.819
1	Pheasant	.438	.009	.059	.053
1	Barn Owl	--	.064	.075	.097
	Mean	3.2	.358	1.1	1.1
	S.D.	2.9	.271	.862	.956

FIGURE 1 - LOCATION OF COLLECTION SITES



THE HACKENSACK MEADOWLANDS DEVELOPMENT COMMISSION
ENVIRONMENTAL RESEARCH LABORATORY
MERCURY IN BIOTA

Intermittent sampling and analysis during 1985 of aquatic and avian biota throughout the Hackensack Meadowlands yielded a survey of mercury concentrations at various levels in the food chain. The resultant data was submitted to the Technical Advisory Group overseeing the clean-up of the Woodridge Mercury Superfund Site as part of a routine monitoring program of mercury in Berry's Creek. This report is intended as the complement to that data, forming a document that will stand alone.

SAMPLING SITES (See Fig. 1)

The Hackensack River and its tributaries north of the mouth of Berry's Creek Canal yielded nine sites for the collection of Brown Bullhead Catfish, Carp, White Perch, and Sunfish. Blue Claw Crabs were collected in Berry's Creek near the Route 3 Bridge. Killifish were collected from Upper Berry's Creek, close to the source of mercury contamination, and from a drainage ditch in Walden Swamp.

Moorhen, mallard (hen), and a redwinged blacbird were collected in Walden Swamp. A goose, gull and pheasant were collected on a closed landfill in Lyndhurst.

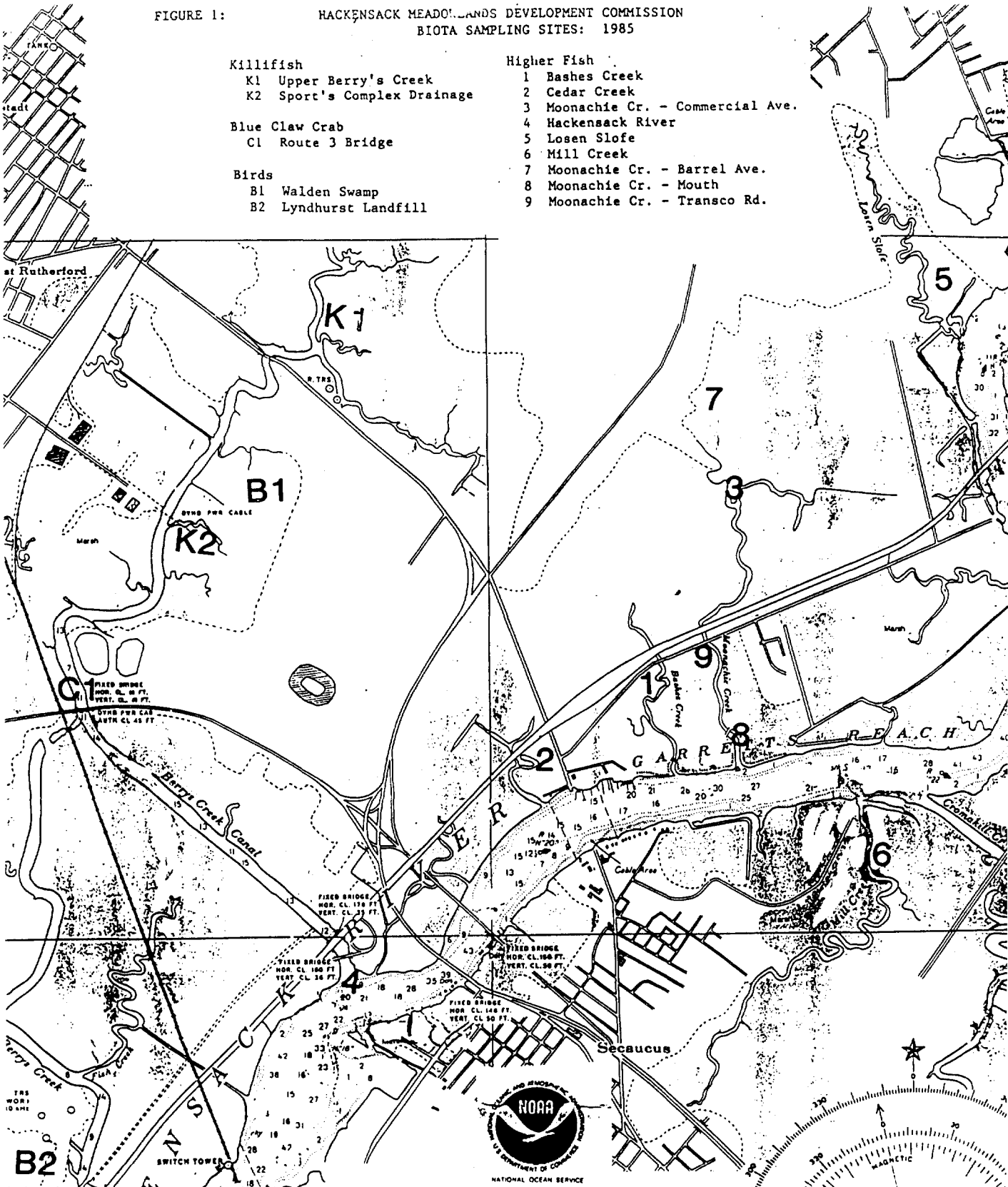
FIGURE 1: HACKENSACK MEADOWLANDS DEVELOPMENT COMMISSION
BIOTA SAMPLING SITES: 1985

Killifish
- K1 Upper Berry's Creek
- K2 Sport's Complex Drainage

Blue Claw Crab
- C1 Route 3 Bridge

Birds
- B1 Walden Swamp
- B2 Lyndhurst Landfill

Higher Fish
1. Bashes Creek
2. Cedar Creek
3. Moonachie Cr. - Commercial Ave.
4. Hackensack River
5. Losen Slofe
6. Mill Creek
7. Moonachie Cr. - Barrel Ave.
8. Moonachie Cr. - Mouth
9. Moonachie Cr. - Transco Rd.



UNITED STATES - EAST COAST
NEW JERSEY

Nautical Miles

Yards

Mercator Projection
Scale 1:20,000 at Lat. 40°47'
North American 1927 Datum

823650070

SOUNDINGS IN FEET
AT MEAN LOW WATER

METHODS

Each fish was frozen at the time of collection. Prior to analysis, the catfish, carp, white perch, and sunfish were dissected to allow for analysis of the gill, muscle, skin and liver. The killifish were analysed whole or using the filet portion only. The crabs were analysed for three tissues: the hepatopancreas, the gill and claw muscle. Similar methodology was followed on the bird samples. Muscle, liver, kidney and feathers were the tissues analysed.

The Perkin Elmer procedure, Analysis of Fish Tissue: Mercury Determination Using a Flameless Atomic Absorption Technique, was utilyzed on all tissues. This does not call for a drying step, therefore all concentrations are calculated on a fresh weight basis.

In summary, between 0.5 and 1.0 gram of tissue is dissolved in concentrated Sulfuric Acid, the mercuric ions are stabilized with a strong oxidant (Potassium Permanganate), then the mercury is reduced to the elemental state and aerated from solution in a closed system. The vapor intercepts the light path at 253.7 nm, and concentrations are calculated from the absorbance correlated to a curve of standard solutions.

The data obtained was reduced using Lotus 123 Release 2 on an IBM PC-XT.

IGURE 2: CONCENTRATIONS OF MERCURY (MG/KG) IN AVIAN SPECIES COLLECTED AT VARIOUS LOCATIONS WITHIN THE HACKENSACK MEADOWLANDS DURING 1985

SPECIES:	LOCATION	TISSUE			
		MUSCLE	LIVER	KIDNEY	FEATHE
MALLARD (HEN)	WALDEN SWAMP	0.03	<0.02	0.59	0.67
REDWINGED BLACKBIRD	WALDEN SWAMP	0.68	0.74	0.54	>2.0
MOORHEN	WALDEN SWAMP	1.10	1.17	1.39	>2.0
MOORHEN	WALDEN SWAMP	1.39	>2.0	>2.0	>2.0
MOORHEN	WALDEN SWAMP	0.21	1.46	>2.0	>2.0
MOORHEN	WALDEN SWAMP	0.59	>2.0		>2.0
GOOSE	LYNDHURST LANDFILL	<0.02	1.67		0.17
GULL	LYNDHURST LANDFILL	0.09	0.18	<0.02	1.26
PHEASANT	LYNDHURST LANDFILL		<0.02		0.27

FIGURE 3: CONCENTRATIONS OF MERCURY (MG/KG) IN CRUSTACEANS COLLECTED WITHIN THE HACKENSACK MEADOWLANDS DURING 1985

SPECIES:	LOCATION	TISSUE
BLUE CLAW CRAB	BERRY'S CREEK	

SPECIMEN	HEPATO-PANCREAS	GILL	CLAW MUSCLE
1	<.02	<.02	0.33
2	<.02	<.02	0.07
3	<.02	0.06	0.25
4	<.02	<.02	<.02
5	1.04	0.43	>2.0
6	0.08	<.02	0.24
7	0.31	0.24	1.42
8	1.67	0.14	0.23
9	0.53	0.12	0.24
10	0.12	0.20	0.58
11	0.64	0.04	0.40
12	0.27	0.11	0.23
13	0.03	0.18	1.00
14	0.18	<.02	0.21
15	0.16	0.06	0.18
16	0.65	0.08	0.37
17	0.30	<.02	1.55
18	0.15	0.28	0.12
19	0.26	0.06	<.02
20	0.24	0.50	>2.0
21	0.22	0.25	
22	<.02	0.17	0.14
23	>2.0	0.19	0.90

FIGURE 4: CONCENTRATIONS OF MERCURY (MG/KG) IN FISH COLLECTED AT VARIOUS LOCATIONS WITHIN THE HACKENSACK MEADOWLANDS DURING 1985

SPECIES:	LOCATION		TISSUE			
	CREEK	AVENUE	SKIN	MUSCLE	LIVER	GILL
CARP		NA	0.12	0.47	0.36	0.05
CARP	MILL		0.49	0.38	<.02	<.02
CARP	LOSEN SLOFE		0.03	0.33	0.30	<.02
CARP	LOSEN SLOFE		0.50	0.17	0.21	<.02
CARP	LOSEN SLOFE		0.28	0.08	0.51	<.02
CARP	MOONACHIE	COMMERCIAL	0.17	0.63	0.38	0.04
CARP	MOONACHIE	COMMERCIAL	0.47	1.11	0.58	<.02
CARP	MOONACHIE	COMMERCIAL	0.18	0.31	0.05	<.02
C ?	MOONACHIE	COMMERCIAL	0.20	0.38	0.15	0.05
CARP	MILL		0.36	0.52	0.07	0.08
CARP	MILL		0.32	0.71	0.89	0.03
CARP	MOONACHIE	TRANSCO RD.	<.02	0.25	<.02	<.02
CARP	MOONACHIE	TRANSCO RD.	0.51	1.08	0.16	<.02
CARP	HACKENSACK	RIVER	0.35	0.75	0.51	0.14
CARP	MOONACHIE	BARREL	>2.0	0.59	<.02	<.02
CARP	MOONACHIE	BARREL	1.98	1.96	0.36	<.02
BROWN BULLHEAD CATFISH	MOONACHIE	BARREL	<.02	0.70	0.37	<.02
BROWN BULLHEAD CATFISH	MOONACHIE	BARREL	0.96	0.79	0.50	0.41
BLUEGILL SUNFISH	MOONACHIE	BARREL	<.02		<.02	<.02
BLUEGILL SUNFISH	MOONACHIE	BARREL	1.36	0.10	>2.0	<.02
BLUEGILL SUNFISH	MOONACHIE	BARREL	0.04	0.51	0.13	<.02
CARP	BASHES		0.08	0.41	0.20	0.11
CARP	BASHES		0.13	1.21	0.11	0.03
CARP		NA	0.03	0.22	0.15	
BROWN BULLHEAD CATFISH		NA	0.19	1.62	1.10	0.25
WHITE PERCH	CEDAR		0.19	0.90	0.94	0.32
WHITE PERCH	CEDAR		1.06	1.58	0.45	>2.0
WHITE PERCH	CEDAR		0.76	1.82	>2.0	>2.0
BROWN BULLHEAD CATFISH	MOONACHIE		0.60	>2.0	0.72	<.02
BROWN BULLHEAD CATFISH	MOONACHIE		0.47	0.97	1.18	<.02
BROWN BULLHEAD CATFISH	MOONACHIE		0.24	1.01	1.20	0.36
BROWN BULLHEAD CATFISH	MOONACHIE		0.07	1.10	0.75	0.81

SUMMARY OF RESULTS

The bird data are summarized in Figure 2. The Moorhen collected in the Berry's Creek Tidal Marsh showed the highest concentrations. The Redwing Blackbird and Mallard from this area possess somewhat lower concentrations, comparable to the mercury obtained from the specimens collected in Lyndhurst. It would be futile to draw conclusions from this data set; the small number of samples and the inability to compare similar species from different areas are the main drawbacks.

Twenty-three specimens of Blue claw crabs were analysed. The results organized by tissue appear in Figure 3. The average tissue mercury concentration is well below the U.S. Food and Drug Administration (FDA) tolerance level of 1.0 ppm; however the average for the claw muscle, the edible portion was 0.56 ppm, which lies above the interim level of 0.5 ppm which was superceded by the new standard in 1978. Thirteen percent of tissues analysed exceeded the FDA tolerance level, while twenty-four percent of the muscle tissue samples exceeded that value.

Figure 4 presents the results of the analysis of the fish collected in the Hackensack River and its tributaries. The number of variables versus the small number of samples confounds any but the simplest of conclusions. For example, White perch yielded the highest average concentration by species (1.3 ppm), however this species was collected from only one location (which

FIGURE 5: CONCENTRATIONS OF MERCURY (MG/KG) IN KILLIFISH COLLECTED WITHIN THE HACKENSACK MEADOWLANDS DURING 1985

UPPER BERRY'S CREEK			FEEDER DITCH TO SPORTS COMPLEX		
SPECIMEN		CONCENTRATION	SPECIMEN		CONCENTRATION
1	WHOLE	<.02	18	WHOLE	1.38
2	"	1.43	19	"	1.38
3	"	>2.0	20	"	1.38
4	"	1.11	21	FILET	0.18
5	"	>2.0	22	"	0.97
6	"	0.72	23	"	>2.0
7	"	>2.0	24	"	0.18
8	"	>2.0	25	"	1.60
9	FILET	1.38	26	"	>2.0
10	"	0.18	27	"	1.68
11	"	0.27	28	"	>2.0
12	"	<.02	29	"	1.16
13	"	0.45	30	"	0.22
14	"	<.02	31	"	>2.0
15	"	0.43	32	"	1.19
16	"	0.95	33	"	0.40
17	"	0.09	34	"	0.34
			35	"	1.24
			36	"	0.39
			37	"	>2.0
			38	"	<.02
			39	"	0.06

therefore resulted in the highest location average as well). The overall average concentration in muscle tissue, the edible portion, was 0.8 ppm. Seventy-one percent of the catfish sampled contained muscle concentrations greater than the 1.0 ppm level (five out of seven).

Figure 5 depicts the values for killifish. While this collection was divided between two sites, little variability exists between these samplings. The overall average value obtained was 1.0 ppm, with a standard deviation of 0.7 ppm. The upper site average was 0.9 ppm (seventeen samples), while the lower site average was 1.0 ppm (twenty-two samples). Fifty-four percent of the samples collected yielded mercury concentrations greater than 1.0 ppm. The analysis included both whole and muscle tissue only concentrations, confounding the results.

RECOMMENDATIONS

A more systematic approach to sampling, including an experimental design which would allow for conclusions to be drawn between sites, is needed. A larger data set including more samples per species would improve the value of conclusions drawn. The proposed Hackensack Meadowlands Development Commission biota sampling plan would provide sufficient quantities of fish at three sites, enhancing the quality of the biota monitoring effort.

SPECIES LIST

BIRDS

Goose *Branta canadensis*

Behavior: migratory

Diet: Seeds, aquatic plants and grasses

Herring Gull *Larus argentatus*

Behavior: resident

Diet: small fish, crustaceans, molluscs, and insects

Mallard *Anas platyrhynchos*

Behavior: migratory

Diet: marsh and aquatic plants, aquatic beetles and their larvae, adults and nymphs of aquatic bugs

Moorhen *Gallinula chloropus cachinnans*

Behavior: resident

Diet: aquatic vegetation, seeds, roots, snails, small molluscs, insects and worms

Pheasant *Phasianus colchicus torquatus*

Behavior: resident

Diet: weed seeds, insects, wild fruits, and occasional small rodents

Redwing blackbird *Agelaius phoeniceus phoeniceus*

Behavior: migratory

Diet: weed seeds and insects

SPECIES LIST (Continued)

FISH

Killifish (mummichog) Fundulus heteroclitus

Behavior: resident

Diet: omnivorous to carnivorous (mollusks, crustaceans, fishes, insects)

Carp Cyprinus carpio

Behavior: resident

Diet: insects, snails, crustaceans, vegetation

White perch Morone americana

Behavior: resident

Diet: crustaceans, fishes, insects

Brown bullhead catfish Ictalurus nebulosus

Behavior: resident

Diet: omnivorous bottom feeder

Bluegill sunfish Lepomis macrochirus

Behavior: resident

Diet: insects, fishes, crayfish

CRUSTACEAN

Blue Crab Callinectes sapidus

Behavior: migratory

Diet: predatory carnivore, scavenger.

Hackensack Meadowlands Development Commission,

Division of Environmental Operations,

One DeKorte Park Plaza,

Lyndhurst, New Jersey 07071

Inventory of Fisheries Resources of the Hackensack River within the jurisdictional Boundary of the Hackensack Meadowlands Development Commission from Kearny, Hudson County, to Ridgefield, Bergen County, New Jersey.

Date Submitted: 5/18/89

Period of Study: February 1987 - December 1988

Investigated by: A. Brett Bragin

Winthrop Frame

Mark L. Kraus

Donald J. Smith

Arthur Goeller

Jeff Grabiec

Ed Konsevick

Sediment Analysis by: Arthur Goeller

Invertebrates Identified by: A Brett Bragin

Report by: Mark L. Kraus, Ph.D., and A. Brett Bragin

Administered by: Anne Galli

This study was supported by the Hackensack Meadowlands Development Commission through Special District Project Funds.

3) A 200 foot long by 8 foot high experimental sinking gill net consisting of four 50 foot panels of 3/4 inch, 1 3/4 inch, 3 1/2 inch, and 4 inch square mesh was used at 3 sites. It was deployed with cinder block attached to both leadlines and two bouys attached to the blocks for marking. Sets were fished for approximately 24 hours. Three (3) sites were sampled using this method.

4) An Indiana Trap Net with a 50 foot leader, made up of 1/2 inch square mesh was fished at 6 sites. The nets were deployed at or near low tide and staked with three wooden dowels 1 5/8 inch in diameter and approximately 14 feet long, one at the lead end and two at the first frame brace. A cinder block was attached to the cod-end. The net was pulled taut until it stood erect and was perpendicular to the shore by means of a floatline attached to the cod-end cinder block. These nets were also fished for approximately 24 hour sets. A total of eight (8) sites were sampled using this method. Fish were identified and counted, and a subsample was measured in the field. Most fish were released, but some specimens were preserved in 10% formalin and taken to the laboratory for further identification or as reference specimens. Numbers in large catches of fish or invertebrates were estimated by counting a subsample.

Most sites were sampled monthly from February 1987 through January 1988. Sites were then sampled quarterly from February 1988 through December 1988.

TN8		Winter 1988 (NOT SAMPLED)	Spring 1988	Spring 1988	Spring 1988	Spring 1988
WATER QUALITY						
Collection No.		—	0730	0757	0760	0795
Date		—	3/29/88	5/11/88	5/24/88	6/13/88
Time		—	1320	1315	1110	1500
Tidal stage		—	Low + 0	Low + 0.5	Low + 0	Low
Depth at low water (ft.)		—	5	4	5	5
Salinity (o/oo)	surface	—	0.0	2.0	0.0	4.0
	bottom	—	—	—	—	—
Temperature (°C)	surface	—	12.9	18.0	19.5	26.8
	bottom	—	—	—	—	—
	air	—	—	25.0	13.0	—
D.O. (ppm)	surface	—	11.2	11.0	2.9	10.4
	bottom	—	—	—	—	—
pH	surface	—	8.2	7.7	7.0	8.2
	bottom	—	—	—	—	—
Secchi (cm)		----	60	50	40	50
Length of set (hr.)		----	----	24	24.5	24

CATCH

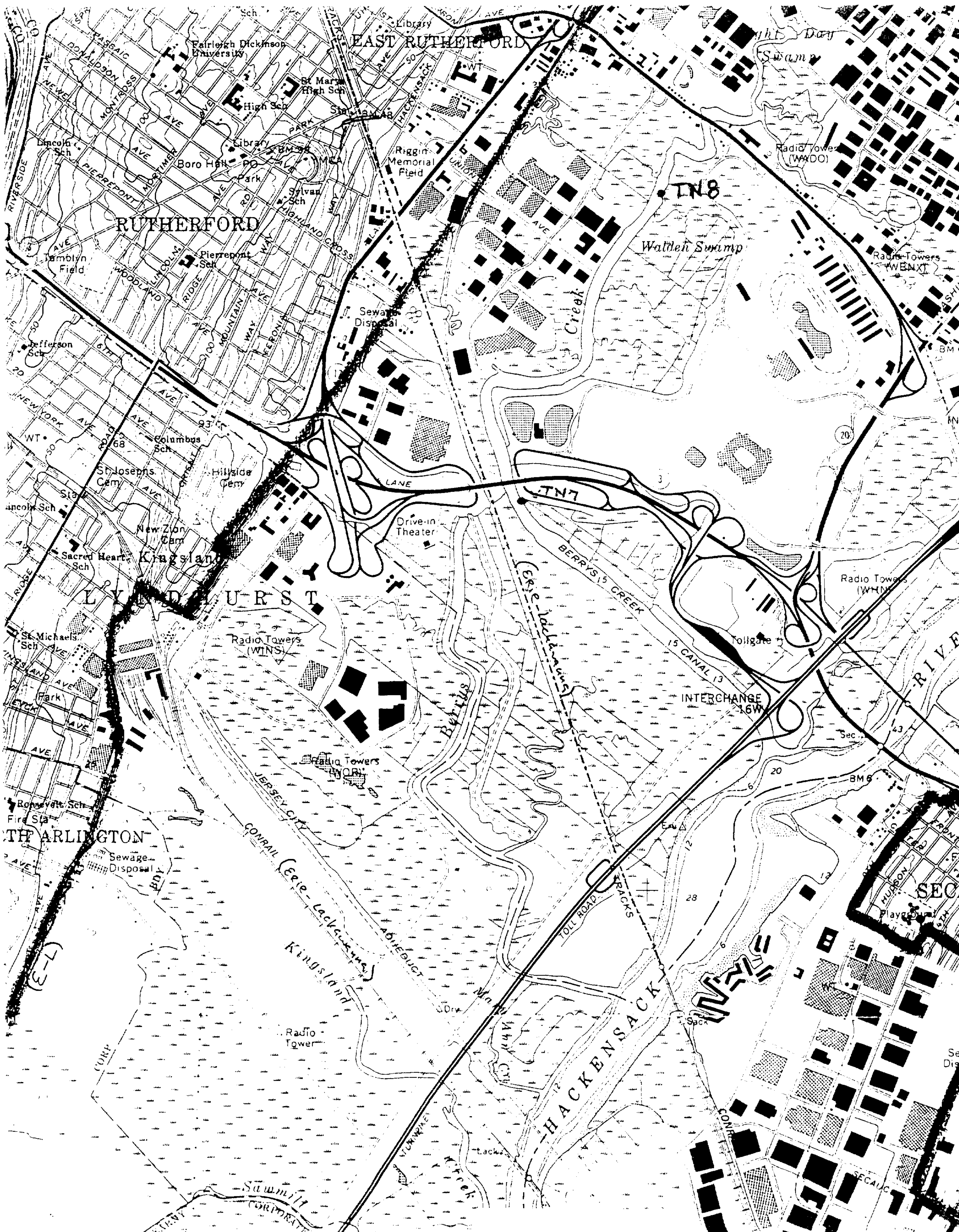
FINFISH

	#	size range	#	size range	#	size range	#	size range	#	size range
brown bullhead	—	—	—	—	8	158-320	7	270-310	—	—
mummichog	—	—	3	—	1	83	2	82-84	2	95-96
pumpkinseed	—	—	—	—	1	65	1	90	—	—
green sunfish	—	—	—	—	4	91-106	—	—	—	—
white perch	—	—	—	—	31	146-275	6	151-253	39	164-268
blueback herring	—	—	—	—	3	177-255	—	—	1	—
carp	—	—	—	—	1	400	1	440	1	400
american eel	—	—	—	—	—	—	2	59-460	—	—
striped bass	—	—	—	—	—	—	—	—	1	104
INVERTEBRATES										
Callinectes sapidus	—	—	—	—	1	96	1	82	—	—

CATCH AND WATER QUALITY COLLECTED AT STATION TN8

TN8		AUGUST 1987	SEPTEMBER 1987	OCTOBER 1987 (NOT SAMPLED)	NOVEMBER 1987
WATER QUALITY					
Collection #		0313	0342	--	0499
Date		8/18/87	9/3/87	--	11/17/87
Time		1215	1155	--	1240
Tidal Stage (hr.)		Low + 0	Low + 1	--	Low + 0
Depth at low water (FT)		5	4	--	3
Salinity (o/oo)	surface	5.0	3.0	--	2.0
	bottom	--	--	--	--
Temperature(°C)	surface	27.5	21.5	--	14.0
	bottom	--	--	--	--
	air	26.0	--	--	16.0
D.O.	surface	11.2	7.9	--	2.2
	bottom	--	--	--	--
pH	surface	7.8	7.5	--	8.9
	bottom				
Secchi (cm)		40	40		50
Length of Set (hr.)		24	24		24.5

CATCH	#	size range	#	size range	#	size range	#	size range
FinFish								
brown bullhead	1	270	--	--	--	--	--	--
goldfish	1	79	2	85-95	--	--	--	--
mummichog	101	69-84	43	33-100	--	--	3	--
pumpkinseed	4	80-93	6	77-92	--	--	--	--
Green sunfish	1	90	5	90-102	--	--	--	--
white perch	5	139-222						
Invertebrates								
(None)								


RUTHERFORD
EAST RUTHERFORD
LYNDHURST
Kingsland
Fairleigh Dickinson University
St Marys High Sch
High Sch
Library
Boro Hall
PO
Park
YMCA
Sylvan Sch
Pierrepont Sch
Tamblyn Field
Lincoln Sch
Jefferson Sch
Columbus Sch
St Josephs Cem
Hillside Cem
New Zion Cem
Sacred Heart Sch
St Michaels Sch
Roosevelt Sch
Fire Sta
Sewage Disposal
Riggin Memorial Field
Radio Towers (WINS)
Radio Towers (WOR)
Radio Tower
Radio Towers (WADO)
Radio Towers (WBNX)
Radio Towers (WHN)
Drive-in Theater
Wallen Swamp
Creek
Berrys
BERRYS CREEK
CANAL
Tollgate
INTERCHANGE 16W
TN 7
TN 8
CONRAIL (Erie-Lackawanna)
JERSEY CITY
AQUEDUCT
TOLL ROAD
TRACKS
HACKENSACK
RIVER
Sawmill
Kingsland
PASSAIC
DONALDSON
MONTROSS
PIERREPONT
MORTIMER
WOODLAND
LINCOLN
RIDGE
MOUNTAIN
WAY
FERONIA
HIGHLAND CROSS
PARK
UNION
HACKENSACK
RIVERSIDE
NEW YORK
ORIENT
LANE
HUDSON
SECAUCUS
CORP
BDY
(E-L)

TN7		Winter 1988 (NOT SAMPLED)	Spring 1988	Spring 1988	Spring 1988	Spring 1988
WATER QUALITY						
Collection No.		--	0729	0756	0759	0796
Date		--	3/29/88	5/11/88	5/24/88	6/13/88
Time		--	1300	1300	1050	1520
Tidal stage (hr.)		--	Low + 0	Low + 0.5	Low + 0	Low + 0
Depth at low water (ft.)		--	3.5	4	4	4
Salinity (o/oo)	surface	--	2.0	4.0	0.0	5.0
	bottom	—	--	--	--	4.5
Temperature (°C)	surface	--	12.4	17.7	20.5	25.6
	bottom	—	--	—	--	25.1
	air	--	--	18.0	13.0	--
D.O. (ppm)	surface	—	13.0	14.4	2.6	10.8
	bottom	--	--	--	--	9.8
pH	surface	--	8.4	8.2	7.1	8.4
	bottom	--	--	--	--	8.1
Secchi (cm)		--	60	50	80	40
Length of set (hr.)		----	24	23.5	24	24

CATCH

FINFISH

	#	size range	#	size range	#	size range	#	size range	#	size range
american eel	--	--	--	--	1	520	--	--	--	--
mummichog	--	--	9	--	5	83-107	15	56-105	1	95
pumpkinseed	—	--	2	58-65	2	59-130	—	--	--	--
Green sunfish	--	--	2	63-80	--	--	--	--	--	--
white perch	--	--	2	150-235	13	142-259	—	--	3	155-257
brown bullhead	--	--	1	265	1	290	3	260-287	--	--
striped killifish	--	—	1	95	--	--	—	--	--	--
carp	--	--	--	--	--	--	--	--	1	325
striped bass	--	--	--	--	--	--	—	--	1	123
blueback herring	--	--	1	250	--	--	--	--	--	—
INVERTEBRATES										
Callinectes sapidus	--	--	--	--	1	72	2	65-112	3	82-103
Palaemonetes pugio	--	--	--	--	20	--	--	--	--	--
Uca minax	--	--	--	--	--	--	1	--	--	--
Rhithropanopeu harrisi	--	--	--	--	3	--	--	--	--	—

CATCH AND WATER QUALITY COLLECTED AT STATION TN7

TN7		AUGUST 1987	SEPTEMBER 1987	OCTOBER 1987 (NOT SAMPLED)	NOVEMBER 1987
WATER QUALITY					
Collection #		0275	0341	--	0500
Date		8/4/87	9/2/87	--	11/17/87
Time		1155	1215	--	1300
Tidal Stage (hr.)		Low + 1	Low + 1	--	Low + 0
Depth at low water (FT)		6	6	--	--
Salinity (o/oo)	surface	9.0	5.0	--	4.0
	bottom	--	--	--	--
Temperature(°C)	surface	28.0	21.5	--	14.0
	bottom	--	--	--	--
	air	27.5	17.0	--	16.0
D.O.	surface	2.2	3.8	--	0.8
	bottom	--	--	--	--
pH	surface	7.3	7.6	--	--
	bottom	--	--	--	--
Secchi (cm)		50	40	--	40
Length of Set (hr.)		24	23	--	24.5

CATCH	#	size range	#	size range	#	size range	#	size range
FinFish								
American eel	1	430	--	--	--	--	--	--
goldfish	--	--	1	70	--	--	--	--
mummichog	82	70-97	15	39-85	--	--	300	65-98
pumpkinseed	4	74-91	1	76	--	--	1	117
Green sunfish	--	--	1	84	--	--	3	82-92
white perch	1	112	--	--	--	--	--	--
Invertebrates								
Rhithropanopeus harrisi	1	--	--	--	--	--	--	--